COAL AGE

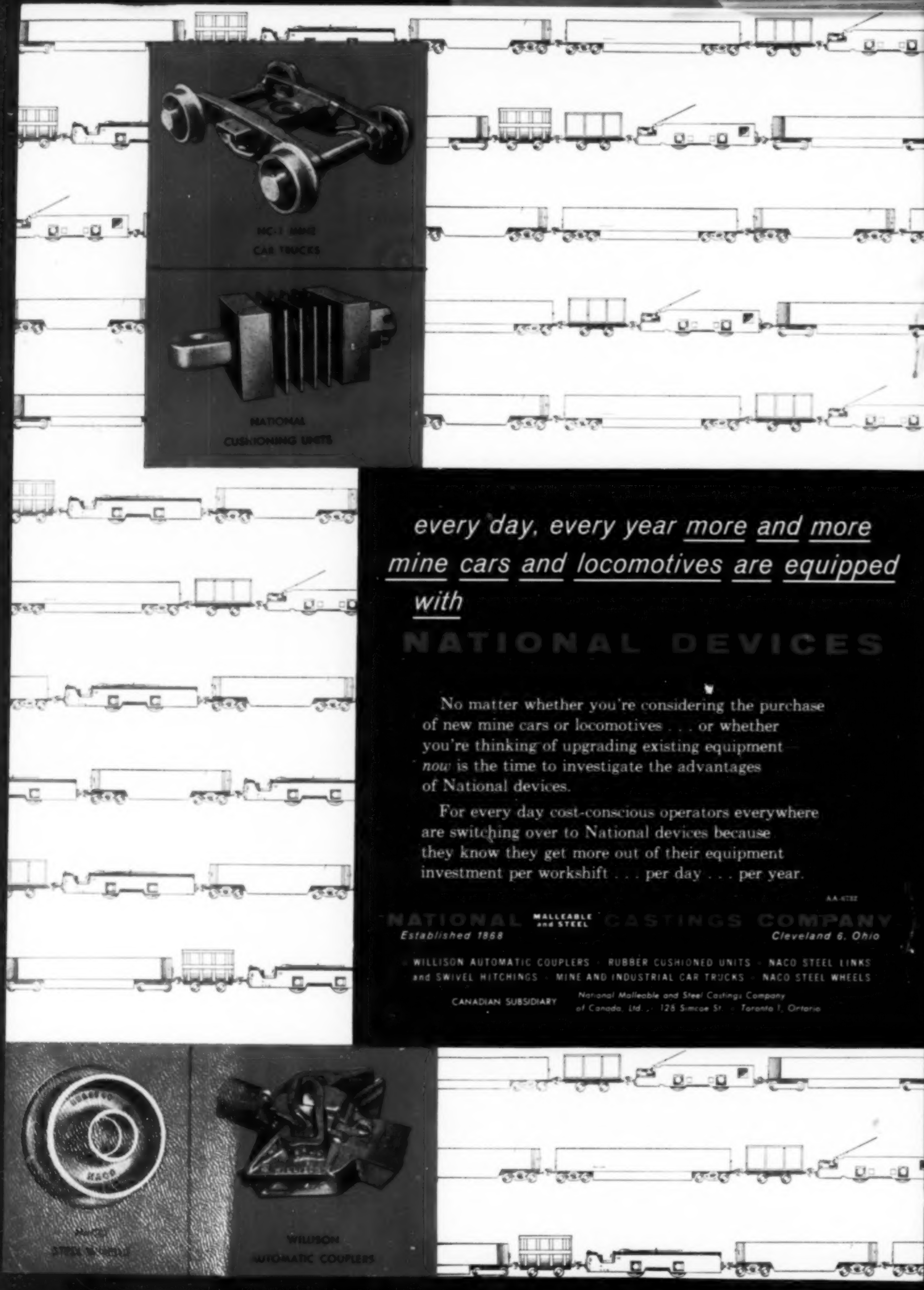
A McGRAW-HILL PUBLICATION

MID-JULY, 1958

PRICE $1

1958 MINING GUIDEBOOK

AND BUYING DIRECTORY ISSUE



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CUSHIONING UNITS
WILLISON
AUTOMATIC COUPLERS
every day, every year more and more mine cars and locomotives are equipped with
NATIONAL DEVICES
No matter whether you're considering the purchase of new mine cars or locomotives . . . or whether you're thinking of upgrading existing equipment — *now* is the time to investigate the advantages of National devices.
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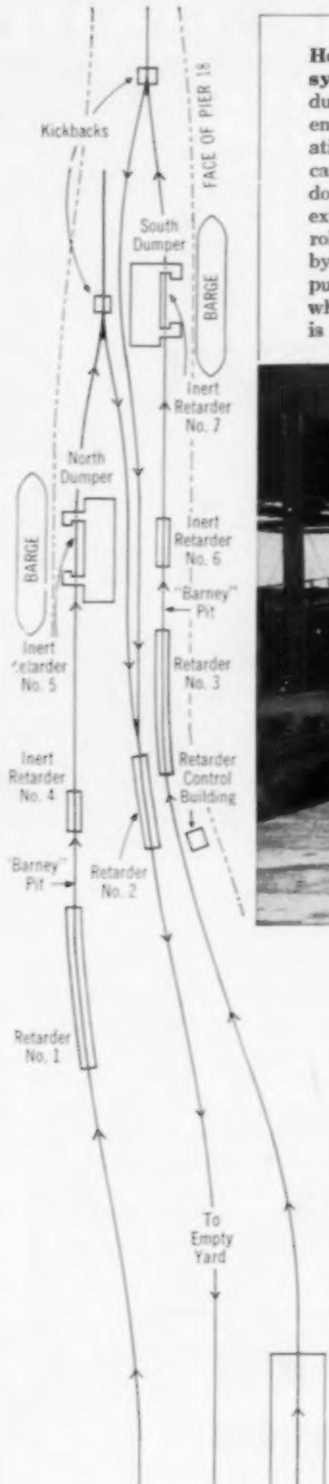
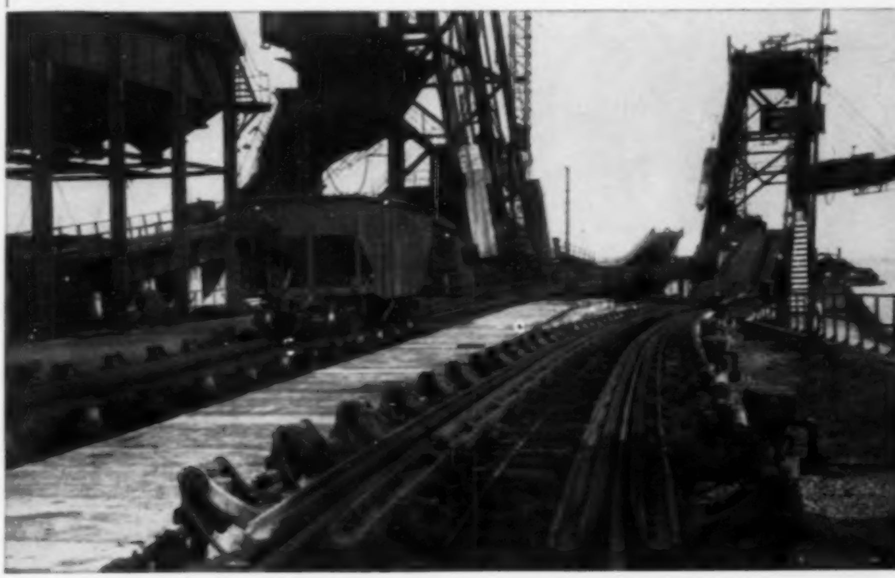


How the new UNION car-retarder system works — Pier 18 has two coal dumping systems and both use the same empty yard. Following through the operation of the North dumper, a loaded coal car leaves the North thawing house, rolls down an incline to retarder No. 1 where its exit speed is reduced, so that when the car rolls on to the "barney" pit, it is stopped by inert retarder No. 4. A "barney" then pushes the car up the slope to the dumper where it is stopped by retarder No. 5. Coal is then dumped into a barge.

The next full car pushes the empty car off the dumper. It goes by gravity through a kickback and spring-switch combination for return through retarder No. 2 to the empty yard. Controls for the power retarders and switches are incorporated in a control machine housed in a new tower building. One operator in this tower surveys the operation and operates the control machine. He has loudspeaker communication with the thawing sheds, the control cabins on the dumpers, and the yard office.



General view of North and South dumpers showing No. 2 and 3 retarders in foreground. Car entering retarder is going to the empty yard.

Fast, low-cost coal handling results from Automation at Pier 18

The Central Railroad of New Jersey recently modernized its coal dumping facilities at Pier 18, Jersey City, N. J. Now, one man sits in a tower, flicks a few levers, and controls loaded coal cars rolling by gravity to the dumpers and empty cars moving from the dumper to the empty yard. Formerly, this job required a crew of car riders and was a costly and hazardous operation.

Now, the job is handled quickly, safely and economically through a system of UNION Electro-Pneumatic Car Retarders. Operating costs have been greatly reduced, and coal is promptly loaded for shipment by barge to New York and New England areas.

What is your materials handling problem? If it involves many carloads of coal, ore or other products, let us show you what can be done with automatic car-retarder systems to increase efficiency and reduce costs. Write for information.

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

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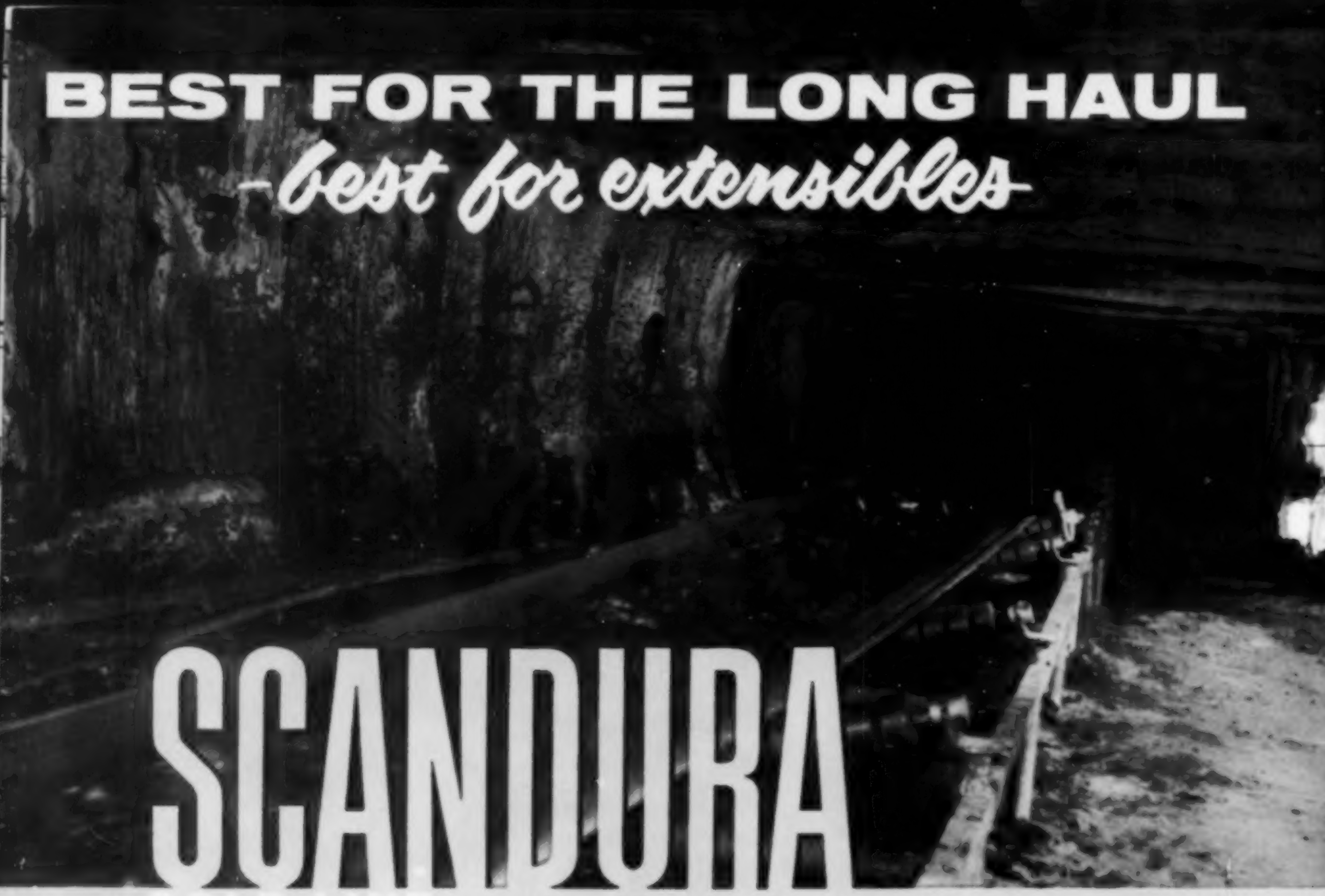


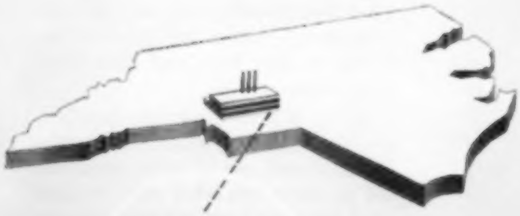
GOLD LINE

MINE BELTING

STRONGER
LIGHTER
MORE DURABLE

. . . moves more tons
—more years

SCANDURA Gold Line Mine Belting—acceptance designation "Fire Resistant U.S.B.M. 28-1"—is more productive because it stays on the job longer without expensive repair. Solid-interwoven, SCANDURA takes a beating without tearing or ripping. With no plies to separate, this great belting is highly flexible—small pulleys can't damage it. Lighter, less bulky SCANDURA trains perfectly, troughs naturally whether empty or loaded, has *two top sides*—thanks to its polyvinyl impact cushion on both faces. • Talk belting with your National Mine man . . . then let SCANDURA Gold Line speak for itself!



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COAL AGE

MID-JULY, 1958

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A McGRAW-HILL PUBLICATION

Member of Associated Business Publications and Audit Bureau of Circulations

COAL AGE MID-JULY, 1958
VOLUME 63 NUMBER 7A

COAL AGE, with which are consolidated **The Colliery Engineer** and **Mines and Minerals**, is published monthly on the 1st with an additional Mining Guidebook number in Mid-July by McGraw-Hill Publishing Co., Inc., James H. McGraw (1860-1948), Founder. PUBLICATION OFFICE, Third & Hunting Park Ave., Philadelphia 40, Pa. See box below for directions regarding subscriptions and change of address.

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COAL AGE articles are indexed by Engineering Index. **Coal Age's** own index is published annually in the December issue.

SUBSCRIPTIONS: Send subscription correspondence and change of address to Fulfillment Manager, COAL AGE, 330 West 42d St., New York 36, N. Y. Subscribers should notify Fulfillment Manager promptly of any change of address, giving old as well as new address and including postal zone number, if any (official post office request). If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change to become effective.

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Mining Guidebook and Buying Directory Issue

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In the new RP38E VACUJET dustless stoper, Ingersoll-Rand has perfected the first practical solution to the problem of dust control for roof bolting and other up-hole drilling operations. It's the *only* stoper that offers you all these important advantages.

Strong Suction Power — vacuum-producing jet ejector built into drill backhead. Can even drill horizontal holes!

Dust Discharged Under Pressure — to a distance of up to 25 ft from drill. Uses ordinary air hose.

Low-Cost Dust Collector — a simple filter and receptacle is all that's required. Even a canvas bag will do.

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For the complete story on this revolutionary new VACUJET stoper, call your I-R man or send today for Bulletin No. 4195.

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COMPRESSORS • CARSETS BITS • ALLOY RODS • HYDRA-BOOM JUMBOS
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PORTABLE,

DURABLE,

ECONOMICAL

...ALCOA ALUMINUM PIPE

FOR TEMPORARY WATER SUPPLY, DRAINAGE, COMPRESSED AIR, STEAM OR FUEL LINES

When portable piping plays a major role in keeping your operations on the move, specify light, strong ALCOA® Aluminum Pipe. Here's why:

PORTABLE . . . One man can easily handle several standard lengths of ALCOA Aluminum Pipe. Small crews can quickly and easily lay long lines of pipe. Pick-up and relaying is easily accomplished to keep pace with moving jobs.

ECONOMICAL . . . Handling by small crews means low laying costs. Long service life adds extra savings.

DURABLE . . . Rugged ALCOA Aluminum Pipe stands up well under heavy abuse. And it's highly resistant to corrosion under the most severe conditions.

Operating efficiency of ALCOA Aluminum Pipe is excellent . . . same friction factor as smooth drawn tube of other metals insures low loss of head.

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"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

MSA's complete product line boosts

ILLUMINATION

EDISON R-4 ELECTRIC CAP LAMP—Brilliant, unfailing beam gives miners the light they must have to work mechanized equipment at its greater capacity, safely. Rugged construction provides dependable service shift-in, shift-out, for years. **EDISON PERMISSIBLE ELECTRIC TRIP LAMP**—Illumination at every angle. High wattage provides great visibility. **M-S-A MINE LIGHTING SYSTEM**—U.S. Bureau of Mines Approved. Cuts down accidents, increases coal output. Provides dependable lighting with instant start circuit that is safe under any and all conditions of ventilation in gaseous mines.

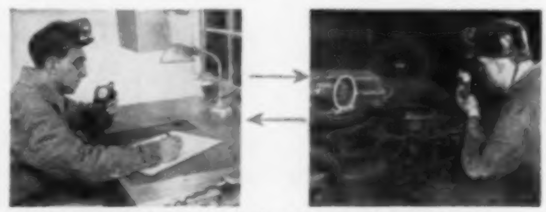
Edison Permissible Electric Trip Lamp

Edison R-4 Electric Cap Lamp

M-S-A Mine Lighting System

COMMUNICATIONS

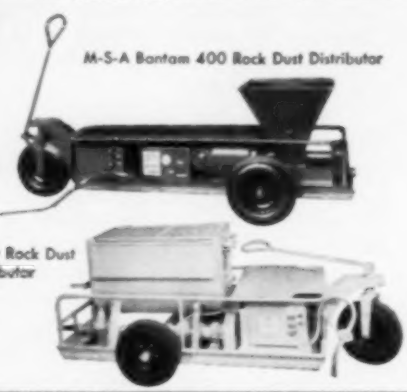
M-S-A MINEPHONE—Sends dispatcher's orders instantly and simultaneously to all motormen, who can receive and reply while trips are in motion. This clear, two-way voice communication keeps trips moving, minimizes waits on sidings. Repair needs are relayed in seconds. Over-all safety is improved because one message alerts all personnel at once.



M-S-A MinePhone keeps haulage in step with mechanization.

ROCK DUSTING

M-S-A BANTAM 400 ROCK DUST DISTRIBUTOR—Discharges 30 lbs. per minute through 400 ft. of hose, or 100 lbs. per minute through 25 ft. of hose. Available now as self-propelled unit. Low height makes it ideal for low coal application and for transporting on any belt or pan conveyor with 16-inch clearance. Also used for fire fighting and wet dust application. **M-S-A SLURRY ROCK DUST DISTRIBUTOR**—With one 400 lb. batch of slurry you can rock dust 80 linear feet of mine entry with this machine. Takes four minutes to mix slurry. Tank capacity is 42 gallons. Discharges 80 lbs. per minute through 600 feet of hose.



M-S-A Bantam 400 Rock Dust Distributor

M-S-A Slurry Rock Dust Distributor

METHANE DETECTION

M-S-A METHANE ALARM—Continuously samples air at working face. Flashing red light warns miners of hazardous concentrations. Automatic; portable; can be mounted. **M-S-A METHANE RECORDER**—Continuously charts methane concentrations in return air. Accurate safety check against unusual gas conditions. Serves as guide for regulating volume of air to maintain proper and economical ventilation standards. Records, and gives visual and audible warnings. **M-S-A—WOLF JUNIOR FLAME SAFETY LAMP**—Dependable, steady flame, guarded by improved ventilation. Easy-to-read graduated chimney. **M-S-A METHANE DETECTOR W-8**—Instant, accurate reading of methane. Ideal for spot checking. Light; portable. **M-S-A METHANE TESTER TYPE M-6**—Pocket sized unit. Indicates methane as low as .2%.

M-S-A Methane Alarm

M-S-A Methane Recorder

M-S-A—Wolf Junior Flame Safety Lamp

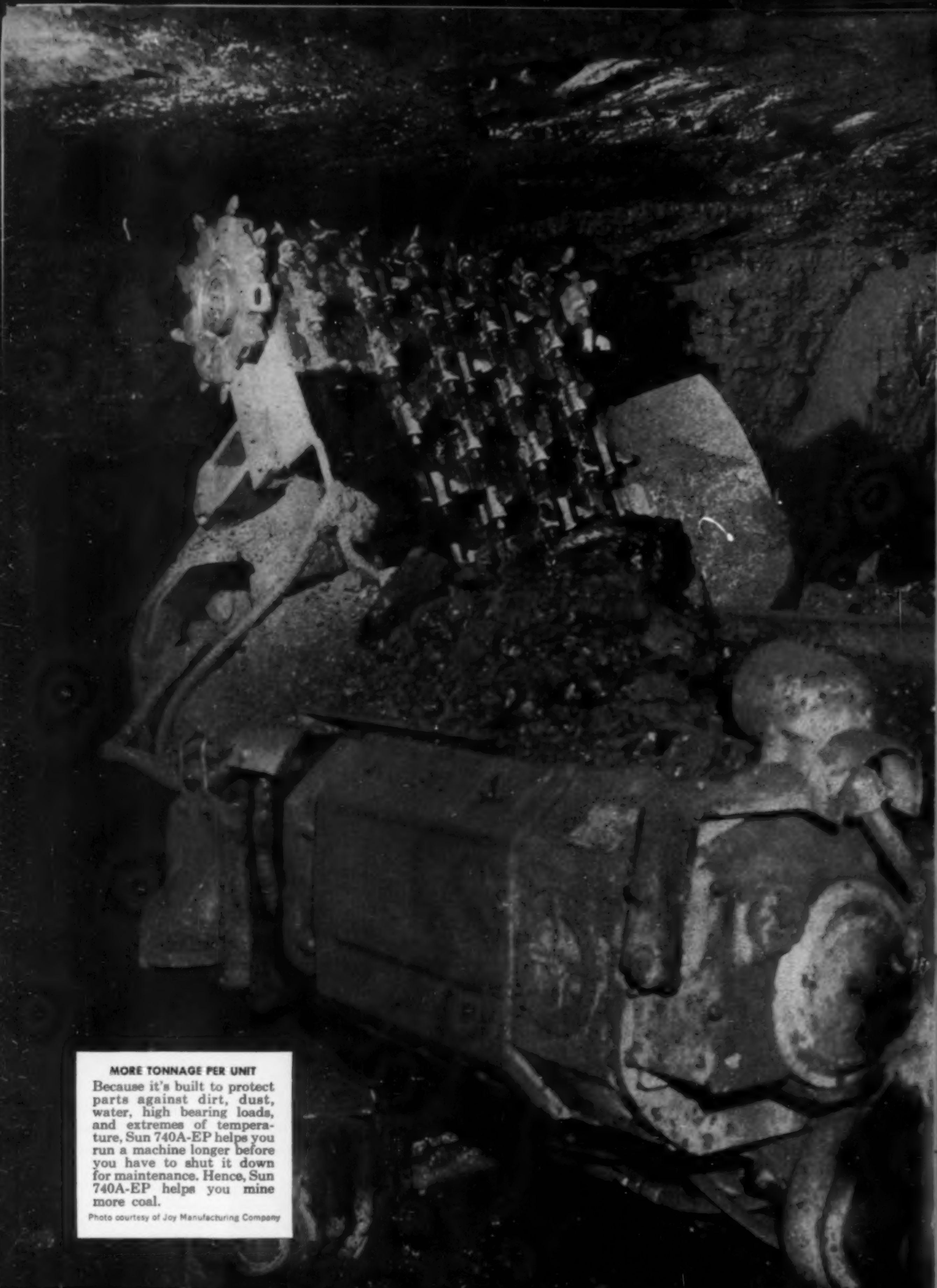
M-S-A Methane Detector W-8

M-S-A Methane Tester Type M-6

When you have a safety problem, M-S-A is at your service. Our job is to help you.

MSA

SAFETY EQUIPMENT HEADQUARTERS



MORE TONNAGE PER UNIT

Because it's built to protect parts against dirt, dust, water, high bearing loads, and extremes of temperature, Sun 740A-EP helps you run a machine longer before you have to shut it down for maintenance. Hence, Sun 740A-EP helps you mine more coal.

Photo courtesy of Joy Manufacturing Company

AMERICAN PULVERIZER COMPANY

Originators and manufacturer of American Rolling Ring Coal Crushers

1275 Macklind Ave., St. Louis 10, Mo.
STerling 1-6100

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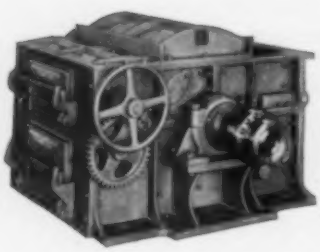


AMERICAN AC TYPE CRUSHERS

Capacities up to 800TPH. Extensively used for the reduction of ROM and lump coal to commercial screenings and stoker sizes. Operates at slow power saving speed, gives positive size control with a minimum of fines. Size of end product can be varied by external adjustments of grinding plate and drop cage.

Only American Crushers have the patented Rolling Shredder Rings which split coal instead of crushing it, thereby producing less fines.

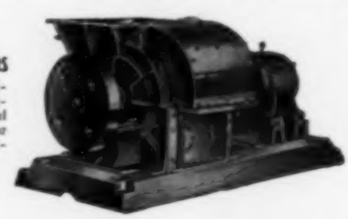
Rings are made of manganese steel and are reversible to give double wear.

WC & WS SERIES

Made in 9 sizes with capacities up to 188 TPH. Very compact—makes ideal installation at mines or in yards underneath coal bin. External adjustments of Grinding Plate and Adjustable Drop Cage permits tailor made sizes to the truckload.

AMERICAN "S" TYPE CRUSHERS

Made in 8 sizes with capacities up to 500TPH for the reduction of ROM and lump coal to Screenings. Also used for crushing Middlings and Picking table refuse.



HEAVY DUTY "S" TYPE

Made in 4 sizes, with capacity up to 500 TPH. This Heavy Duty "S" Type Crusher reduces ROM Coal, gob, rock, slate, sulphur balls, etc. without oversize and eliminates the need for pickers. Pays for itself in short time in savings of labor and recovery of coal imbedded in impurities.

SAMPLE CRUSHERS

Made in two sizes with capacities up to 2000 lbs. per hour. Sampling hopper gives a 5%—10%—15%—20% Sample of The Sample—For larger capacities we recommend the American "WC" or "13" Series with capacities up to 12 TPH.

COMPLETE LINE

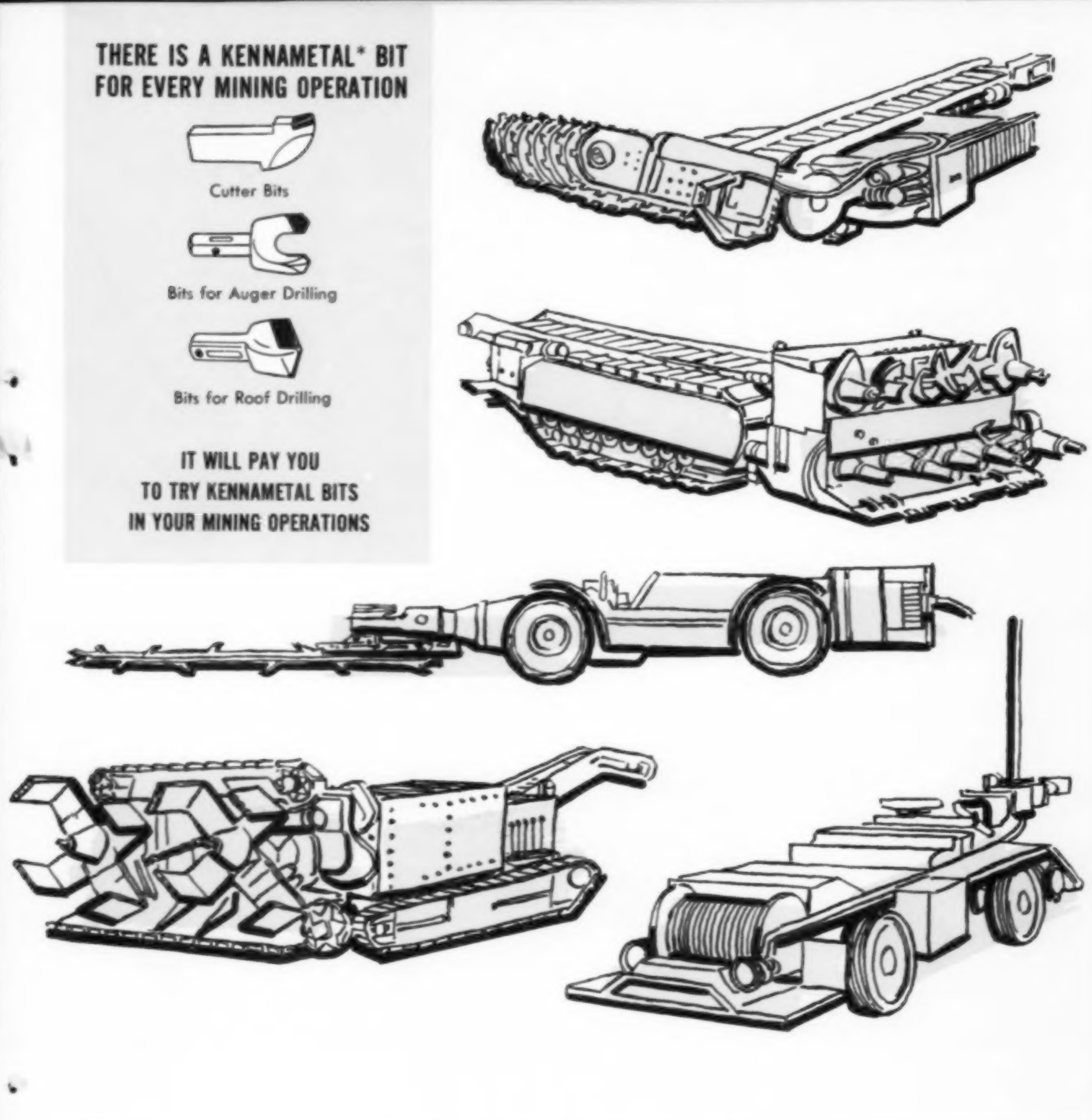
From large tonnage crushers with capacities up to 800TPH to Coal Sample Crushers, in a wide range of models and sizes, all custom designed to fit your specific operation.

EXPERIENCE

American has manufactured reduction equipment exclusively since 1908. American Rolling Ring Coal Crushers are in use all over the world and are famous for their dependability, low operating cost, and high output of uniform product.

ENGINEERING SERVICE

The Engineering Staff and experimental laboratory of American Pulverizer Co. provides a valuable service for analysis and recommendations of the proper type and size crusher for your operation.


THERE IS A KENNAMETAL* BIT
FOR EVERY MINING OPERATION
Cutter Bits
Bits for Auger Drilling
Bits for Roof Drilling
IT WILL PAY YOU
TO TRY KENNAMETAL BITS
IN YOUR MINING OPERATIONS

AVAILABLE
A KENNAMETAL BIT FOR EVERY MINING NEED

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THERE IS A COMPLETE LINE OF KENNAMETAL CUTTER BITS, DRILL BITS, ROOF BITS, AUGERS, PINNING RODS, ACCESSORIES

Style U7R

Style U8

Style U7RAB

Style U7T

Style U3RA

Style RD

Style D


Style DB

Style DL

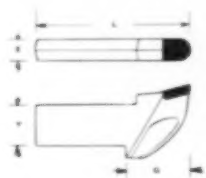
Style FDC

Style FDL

Style DK

KENNAMETAL Cutter Bits

KENNAMETAL Mining-Machine BITS combine hard, cemented carbide cutting edges with a bit body of the highest quality steel, heat-treated to the correct hardness for machine operation. Special design and tough shank construction provide top coal cutting efficiency with long service life. Savings in production time, fewer bit changes, less machine maintenance add up to reduced cost per ton of coal. Ask your Kennametal Representative for reports from coal operators everywhere of top performance with Kennametal Cutter Bits.



Catalog Number	Dimensions			
	G (Gage)	X	Y	L
U1	1½"	½"	1"	3⅝"
U4	1¾"	½"	1"	3⅝"
U7	1¾"	½"	1"	3⅝"
U7T	1¾"	½"	1"	3⅝"
U8	1½"	½"	1"	3⅝"
U9	1⅝"	⅝"	1 3/16"	3 7/16"
U10	1¾"	½"	1"	3⅝"
U11	1½"	½"	1"	3⅝"
U10A	1¾"	½"	1"	3⅝"
U3R	1¾"	*	1"	3⅝"
U3RA	1¾"	*	1"	3⅝"
U6R	2½"	¾"	1¼"	3⅝"
U7R	1¾"	½"	1"	3⅝"
U7RB	1¾"	*	1"	3⅝"
U7RA	1¾"	½"	1"	3⅝"
U7RAB	1¾"	*	1"	3⅝"
U8R	1½"	½"	1"	3⅝"
U8RA	1½"	½"	1"	3⅝"
U9R	1⅝"	⅝"	1 3/16"	3 7/16"

*Although the shank width for the U3R and U7RB Series is ½" at the back, the enlarged sections of the shank throat provide an effective width of 1" for the U3R Series and 11/16" for the U7RB Series.

KENNAMETAL Drill Bits

Designed for drilling both coal and rock, Kennametal Drill Bits provide long drilling life at low cost per ton. Even in successive layers of boney, clay, slate, shale and other hard impurities, the sintered carbide cutting edge withstands hard, tough service. And drilling can be continued for several shifts under average conditions, without time off for bit changing. Other features of Kennametal Drill Bits include fast chipping action, a rapid rate of penetration, and a smooth flow of cuttings.

Catalog Number	Dimensions		
	D	H	L
RB-1⅜	1⅜"	½" sq.	2"
RB-1½	1½"		
RB-1⅝	1⅝"		
D-1¾	1¾"		
D-1⅞	1⅞"		
DD-1⅞	1⅞"	⅝" sq.	2¼"
DD-2	2"		
DD-2¼	2¼"		

Catalog Number	Dimensions		
	D	H	L
DB-2¼	2¼"	1 3/16" Hex.	2¼"
DB-2½	2½"		
DB-2¾	2¾"		
DB-3	3"		
DBB-3	3"	1⅛" Hex.	3"

Styles DL and DBL are available in the same sizes and shank styles D and DB Bits, from 1¾" to 3".

KENNAMETAL Roof Drill Bits

The design of Kennametal Roof Drilling Bits and the selection of carbide grades for this service make possible the use of high thrust and torque to get holes through rock of various degrees of hardness and toughness without fracture of the cutting edges. Water ports are provided for cases where wet drilling is used. For more refractory work, use Kennametal Rock Bits.

Catalog Number			Dimensions		
Style FDC	Style FDL	Style DK	D	H	L
FDC-1⅜	FDL-1⅜	DK-1⅜	1⅜"	½" sq.	1½"
FDC-1 7/16	FDL-1 7/16		1 7/16"		
FDC-1½	FDL-1½	DK-1½	1½"		
FDC-1⅝	FDL-1⅝	DK-1⅝	1⅝"		
FDC-1¾			1¾"		
FDH-1⅞			1⅞"		
FDDH-1⅞			1⅞"	⅝" sq.	2¼"
FDDH-2			2"		
FDDH-2¼			2¼"		
FDBH-2¼			2¼"	1 3/16" Hex.	

KENNAMETAL SPECIALTIES AND ACCESSORIES

KENNAMETAL Pinning Rods

These Pinning Rods are of special design to make roof bolting more practical wherever standard drills are used. Generally, the rod shanks are of the twist type to fit regular Kennametal Drive Sockets, but square and other types are made for special applications. Usually six inches of scroll is provided at the bit end of the rod.

Style PR-13

Style PRF-13

PR Rods with Twisted Shank	
Rod Length	Cat. No.
2′	PR 13-2
3′	PR 13-3
4′	PR 13-4
5′	PR 13-5
6′	PR 13-6

PRF Rods with 1⅛" Square Shank	
Rod Length	Cat. No.
2′	PRF 13-2
3′	PRF 13-3
4′	PRF 13-4
5′	PRF 13-5
6′	PRF 13-6

PRSB Rod (Extension) ½" Square Shank	
Rod Length	Cat. No.
1′	PRSB-1
2′	PRSB-2
3′	PRSB-3

Other lengths in 6" multiples available.
All types available with no scroll on request.

KENNAMETAL Augers

These augers are made of the highest quality steel available, giving them great strength and maximum resistance to bending. Life of the scroll is greatly increased by flame hardening during fabrication. Available styles of shanks: twist, threaded, and snap-button types. Smaller diameter augers have solid centers, while larger diameters are tubular.

Also Kennametal Sockets, Studs, Couplings and Adapters.

Snap-Button Shank Auger

Twisted Shank Auger

Threaded Auger

Twist Shank Augers

Catalog Numbers						
Dia.	1⅜"	1½"	1⅝"	1⅝"**	2"	2½"
Chuck	½" sq.	½" sq.	⅝" sq.	⅝" sq.	13/16" Hex.	13/16" Hex.
3 ft.	A13-3	A14-3	B16-3	BB16-3	H20-3	H24-3
4 ft.	A13-4	A14-4	B16-4	BB16-4	H20-4	H24-4
5 ft.	A13-5	A14-5	B16-5	BB16-5	H20-5	H24-5
6 ft.	A13-6	A14-6	B16-6	BB16-6	H20-6	H24-6
7 ft.	A13-7	A14-7	B16-7	BB16-7	H20-7	H24-7
8 ft.	A13-8	A14-8	B16-8	BB16-8	H20-8	H24-8
9 ft.		A14-9	B16-9	BB16-9	H20-9	H24-9
10 ft.			B16-10	BB16-10	H20-10	H24-10
Bit Sizes	RD-1⅜ RD-1½ FDC-1⅜ FDC-1½	RD-1⅝ FDC-1⅝ D-1⅝ DL-1⅝ D-1⅞ DL-1⅞	DD-1⅝ DD-2	DD-1⅝ DD-2	DB-2⅛ DB-2½	DB-2⅝

A13 augers are also available as AF13 with 1⅛" square shanks.
**BB augers are heavy duty style.
Extension augers with threaded couplings are available.

Snap-Button Shank Augers

Cat. No.		Dimensions	
3" long	4" long	Dia.	Chuck
SB13-3	SB13-4	1⅜"	½" sq.
SB14-3	SB14-4	1½"	
SB16-3	SB16-4	1⅝"	⅝" sq.
SB20-3	SB20-4	2"	
SB24-3	SB24-4	2½"	

Also available without snap buttons.

Style BR Socket

Bits for Overburden Drilling

Kennametal Style FS Finger Bits provide exceptional stamina and speed in drilling large diameter holes in hard rock.

The Kennametal Style SD bit is a three-pronged bit used in sizes from 3¾ to 9-inch diameter for drilling holes to blast overburden and for other special uses. The UD bit, for similar applications, uses replaceable cutters.

Style FS

Style SD

Style UD

For Better Mining Today . . .

WHETHER DEEP, STRIP OR AUGER, the overriding goal in coal mining is keeping the key units—miners, loaders, strippers—working at capacity as close to 100% of the time as possible. The job involves all echelons of operating management down to and including the section or pit boss, as well as engineers and other staff men. With this as the key, running a section, a pit or a mine takes in the following:

1. **Establishing Production Standards.** Assuming a continuous miner with a rated capacity of 6 tpm or a dragline rated at 1,000 cu yd per hr, will they produce that much day in and day out? Obviously not, but there is a proper figure, which can be arrived at for all conditions by the application of industrial-engineering principles. Production standards established on this basis mean that it is possible to attain the maximum in efficiency. Savings of up to 25% or more in total mine cost have been achieved in this fashion.

2. **Synchronized Operation.** Where several equipment units work together balance in the cycle is imperative. A cutter unable to keep up with a loader, or a drill unable to prepare sufficient burden for a shovel, reduces overall output while the wage bill remains the same, thus running up the cost. Balance between units and equalizing the working efforts of crew members are, as a matter of fact, two of the major goals in industrial engineering.

3. **Performance Records.** The need for records will vary, but whatever the variation, the daily, weekly and monthly records finally decided upon should be detailed enough so that present performance can be compared with the past and with the performance of other sections, pits or departments—or better yet with engineered standards. Delay records are as important as production records, since they provide a basis for concrete steps to avoid a recurrence.

4. **Trained Men.** This does not mean only formal courses or schooling, though these are growing in number and scope, particularly to meet the needs for maintenance and other special skills. But even without formal indoctrination, the alert supervisor, who will also be the better for training, can do much in instilling good work habits and a proper regard for safety.

5. **Rated Voltage.** Voltage lower than the nameplate rating not only slows down equipment, particularly DC; it also breeds a don't-care attitude among crew members and results in more trouble and higher maintenance. Good voltage at the machine means good power—a vital factor in performance and cost today.

6. **Expert Machine Care.** Low cost today depends on keeping machines running as much of the time as possible at rated capacity. Stoppages resulting from machine failures cost as much in idle time as any other interruption. Skilled preventive attention is the answer.

7. **Supplies When Needed.** Small breakdowns can have severe consequences when it is necessary to send to some distant point for a part that should have been in the production area. The moral is to make sure that supply items of the right type are at the right place at the time they are needed.

8. **Transportation When Needed.** Whether the job is moving coal or spoil, particularly coal, production stops when the transportation facilities are idle. The answer is a system and equipment that will provide the degree of "continuity" necessary for uninterrupted production.

9. **Incentive.** A powerful means of getting the most in effort and results from managers and men is some form of reward or recognition for above-average performance. It may be money for extra tons per day, but there are other incentives of an intangible, though still potent, nature. Such things as merely pointing out the crew standing, with praise if at the top or appropriate comment if down the list, usually can stimulate competitive spirit to a marked degree, with consequent salutary effect on production and cost.

10. **Safety Always.** Last but by no means least in any set of principles for running a mine or section is constant emphasis on safety. The payoff comes from not only reduced accident costs but from the fact that safe methods are efficient methods—and safety-minded men are better producers.

The Coal Age Mining Guidebook

AGAIN EXTENSIVELY REVISED and brought up to date with new methods and equipment developed in the past year, this 1958 edition of the *Coal Age* Mining Guidebook and Buying Directory brings the following services to men engaged in coal mining, whatever their responsibility:

1. **Practical, down-to-earth, up-to-date and continuously useful data on basic principles, modern mining practice, and modern equipment and materials.**

See General Index, p 3, and detailed indexes of the material at the start of each division.

2. **Special data on equipment, materials and services offered by manufacturers.**

See Advertising Section (Index can be found inside the back cover).

3. **Where to buy equipment, materials and services. This service is arranged by products and includes trade names.**

See the Buying Directory beginning on p 185 of this issue. In addition, a list of sales offices and representatives of advertisers in this issue, arranged by states, starts on p 301.

Cost Control

The Industrial-Engineering Concept—What it is and how to organize to put it into effect, including selection of personnel.

Time Study and Methods Revision—Taking and compiling time studies; establishment of standards; the how and why of methods revision.

Incentives—What they are and are not; how to set up to make incentives work.

Control Methods— Production and delay reports; the budget as the final control step.

ABILITY TO CONTROL COST in turn means ability to keep it to a minimum—positively and continuously. And ability to control total cost likewise means ability to control all the individual costs. This is the goal of the "industrial engineering" concept which, in its broadest form, includes the indoctrination of top management in control techniques, the addition of industrial engineering to the management setup, the participation of operating management and supervisors, the use of time studies for improving methods and setting standards, the adoption of production incentives, and the setting up of control machinery, including expenditure budgets.

The rewards of a good industrial engineering approach to operation are impressive, with several organizations reporting cuts of 25% or more in direct mining cost, and up to 50%, in a few instances, in face cost.

Cost control through industrial engineering is based upon measuring actual costs against potential costs, rather than actual costs against those of the past. Thus, it is basically the more realistic approach, since it starts with a carefully established yardstick and ends with a production and cost budget providing final control.

The principles of achieving minimum cost at the face, modified as necessary, permit the planning of haulage, the organization of shop work, the estimating of the effects of nonroutine jobs on cost, and the streamlining of paper work.

Forecasting of costs is another area in which industrial engineering can be most helpful. Labor cost, as a matter of fact, tends to stabilize as a result of time studies and methods revisions, leaving as the major variables such things as breakdowns and changes in equipment, methods and conditions. What, for example, will a new machine do for cost? Taking the guesswork out of buying prevents either buying a unit that will not provide the necessary benefits, or failure to buy because of lack of definite information on results.

Organizing for Control

Adoption of the cost-control principle means a change in the management setup of the company through the adding of a new function. Some companies can choose between two possible methods of adding this function. With others, particularly those in the smaller group, circumstances may limit the possibilities to only one. The major choices are:

1. Establishment of the company's own industrial engineering, standards or cost-control department.
2. Contracting the job of setting standards and control systems to an outside firm specializing in such work.

Both methods are presently employed in coal mining, and in a few instances where the job is done by the coal company it may fall to the lot of one man—sometimes the superintendent—with help from outside and from his foremen to handle the job. Normally, however, this arrangement is less effective than when the job is left to the specialist or specialists, whether on the company payroll or outside.

The specialist in the company organization may be hired as such, or he may be a staff member trained for the job. Where departments are of some size, a common practice is to hire a man (or men) already qualified in industrial engineering and then depend upon him to train others as necessary. Where training is done, it must have as its objective qualified specialists also, since the effectiveness of industrial engineering reflects knowledge of the subject.

CONVERTING MINING MEN—Some experienced organizations lean to training mining men rather than bringing in industrial engineers on the basis that it is easier to instill the industrial engineering know-how into the mining man than to train the inexperienced outsider in mining. Judgment is involved in certain operations and the experienced mining man with industrial-engineering know-how is better able to come closer to the right answer than a man with no mining experience. As an example, in arriving at "normal" times in time-study work, the experienced man is better able to judge whether the man doing the job is working at "normal" or some other rate—a necessary step in adjusting to final times.

The greatest advantage of building a production-standards department around experienced mining engineers and mine foremen is that the new concepts and methods are presented to the operating personnel in understandable terms, and safety and mining laws are fully considered. Since the basic data are taken and compiled by members of the standards department and the standards are installed and maintained by operating officials, both groups must be able to work as a team.

Selection of the personnel to inaugurate and carry on the program is one of the most important of the organizational steps. It presupposes, however, thorough indoctrination of operating management in the objectives of the program, their importance in achieving ultimate success, and the methods to be followed in setting and maintaining the standards on which the results are based.

DESIRABLE QUALITIES—In selecting men for industrial-engineering work, experience has shown that certain personal characteristics are important. They include: ability to lead people and get them to cooperate; understanding of and ability to use mathematical and basic engineering techniques accurately; analitical interest and ability; and the patience and tenacity to see a project through to its conclusion.

Another key element is the understanding and cooperation of the foremen. There is unanimous agreement that they also must understand the aims and objectives in standards-setting, and must be familiar with and able to apply standards-setting principles. Thus, all foremen should be able to make time studies and apply the results.

The organizational process therefore breaks down approximately as follows:

1. Indoctrination of operating management in objectives and methods.

2. Selection of qualified people (or their development by the necessary training) to put the program into operation and keep it going.

3. Incorporation of the foremen into the program on a basis of active participation.

How the industrial engineer will be fitted into the organization is another decision in setting up for cost control. Two of the more common approaches are:

1. Separate status for production and standards, with care, however, to keep standards on an equal plane. This means making industrial engineering a staff or fact-providing function though ranking it in importance with the production function.

2. Allocating to industrial engineering a degree of line or production responsibility in addition to staff status.

Ten Keys to Effective Cost Control

1. Management acceptance and understanding of the basic principles.
2. Active participation of supervisors.
3. Employment or training of industrial engineers or their equivalent.
4. Allocating to industrial engineering or cost control the rank and authority necessary to achieve the desired results.
5. Adoption of the time-study principle.
6. Methods revision based on time study and analysis of both cycle and equipment.
7. Establishment of standards of performance, with provision for necessary re-study and review.
8. Establishment of incentive-payment plans for foremen or foremen and workers (optional, but commonly accepted as one of the final steps in getting minimum cost).
9. Development of production and delay reports based on standard times or performances, with provision for rating each new section or operation.
10. Adoption of cost and production budgets.

Which plan, or modifications thereof, to adopt depends, in the last analysis, on individual circumstances. The goal is to provide the industrial engineering or standards department with the status and authority necessary to insure that its operations pay off. Too much authority can be bad—and also too little.

Data Collection

A major aim in industrial engineering is achievement of a production system that will consistently provide the lowest cost. Normally, this means, among other things, continuous study and modification of methods and equipment to keep cost always as low as practical. A second major aim may be the establishment of incentives to stimulate the best efforts of management and men and thus reduce cost in that direction as well as others.

The time study is the tool employed in arriving at methods changes—and eventually in establishing incentives. Barring a major change in equipment or conditions, the best method is the one in which all operations are in proper balance and neither men nor equipment lose time waiting on each other. This does not mean that other higher-capacity equipment would not increase productivity and cut cost, but only that with existing key units a state of balance is the desired goal.

BASIC STEPS—Steps in collecting the necessary basic data, or "elemental" or "raw" times, are basically the following:

A. Break the operation being studied down into the smallest practical elements that can be timed. The goal is to have a breakdown that will permit each element to be timed repeatedly without hesitation, and by anyone with a list of the elements. The first step therefore is to study the operation long enough to be able to break it down into elements that can be precisely described and timed. The description of the elements includes the "Start" and "Stop" points, arranged so that the stop point of one element is the start point of the next.

As an example, the process of unloading a shortwall cutter off a crawler truck might be oversimplified into two elements:

1. Tram.
2. Unload.

Actually, the breakdown that would provide a really useful working basis might be as follows:

1. Tram.
2. Unload tools.
3. Get in position to pull off rope.
4. Pull off rope.
5. Cut jack hole.
6. Set jack.
7. Tighten rope.
8. Position safety jack.
9. Unload.

B. Describe the elements so that they are recognizable by anyone familiar with the operation. In addition to this description, work up single-word summaries or symbols that can be quickly written by the man who actually does the studying.

An example of an element description in auger mining is as follows:

Head back:

Start: When drilling stops. Include uncoupling chuck from flights and tramming drilling head back.

Stop: When head stops rearward motion.

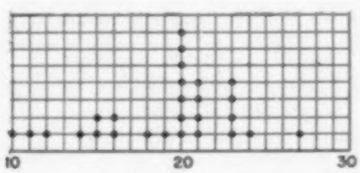
C. Take the actual times, using a form on a clipboard and a stopwatch. A ruled sheet of paper may be employed or a form may be mimeographed or printed for the purpose. The watch should be of the snapback variety graduated in hundredths of minutes.

Determining Standard Times

Time study of a particular operation should be continued long enough to be sure that representative times are obtained. This is necessary even if the goal is only methods revision, but is even more important if an incentive system is to be set up.

Some recorded times will show considerable variation. This is especially true of certain operations such as breaking rock, which naturally is completely different from sumping a continuous miner. But whether the variation is little or great the question becomes one of determining the basic time.

One method is to average the times. Another is to chart them by frequency, as in the accompanying illustration. In this example, the most-frequent time was 20/100 sec. The arithmetical average would have been 19/100 sec. The frequency chart, some industrial engineers contend, automatically eliminates abnormal times but at the same time keeps them available for inspection.



TIME CONVERSION—Having obtained the "average" or "typical" elemental or "observed" times, the next step is to convert them to "normal" times, and then include the proper adjustments for fatigue and the man's personal needs. The conversion of the "observed" time to "normal" is one of the areas in which accurate judgment is required. Normal pace is the working speed of a qualified operator at daywork tempo. (Many define this as the equivalent of walking at 3 mph on smooth, level ground without load.)

If, as an example, the observed time for a particular operation is 2 min and the time-study man concludes that the man is working at 10% faster than the normal pace, the observed time is increased to 2.2 min to obtain the "normal" time. This step is an essential one regardless of the particular goal. Otherwise, any attempt to revise methods, as an example, would fail because the times used were unrealistic, being either too great or not enough.

If the goal was also establishment of an incentive system, accurate determination of "normal" times is even more vital, since an incorrect normal will result, in one direction, in excessive earnings or, in the other, in little or no extra money, with consequent discouragement and failure.

FATIGUE ALLOWANCES—No man can work all-out for a full shift without rest. Consequently, fatigue must be allowed for by an adjustment of the "normal" times to convert them to "standard" times for performance measurement. The allowance varies with the job. A loader operator, for example, might be given an allowance of 10%, while the helper, with shoveling and other heavier tasks, might be allowed 25%. Next, the man must be accorded time for personal needs, for which an allowance of 5% usually is made. Thus, if the normal element time was 2.2 min, it would be increased by 15% in one instance and 30% in the other to achieve a "standard" time—a time matched to the pace the man could keep up the entire shift.

Since many operations, such as loading out a cut of coal, include both manual, or "man-paced," and machine, or "machine-paced," elements, and men and machine are expected to finish together, it is necessary to increase any times recorded for the machine part of the cycle by the same allowances granted to the men. For example, a loading machine could complete a cut in 18 min of actual machine time cut after cut. The helper, shoveling up loose coal and doing other work, could finish the first cut in 18 min with the machine but he would have no rest or other time out and manifestly could not keep the pace the entire shift. Thus, a standard set on the rate the machine could attain would be impossible for the man to maintain over the shift, so if machine time was used it would have to be increased so that the man could keep up and, if an incentive system was in operation, reach incentive rate.

Methods Revision

A major goal in industrial engineering is the development of working methods that will provide the lowest cost. In coal, face methods are a prime target.

When an industrial engineering program is adopted the aim in the initial time studies is to start on a revision of methods—and possible equipment—to attain minimum cost. Once the revision is completed, time study then is employed to see if the desired results are being achieved and further, to assess, if desired, the possibilities of new types of production facilities in place of those originally studied.

Time study therefore is the foundation for methods study. Balance is the goal, which in turn means eliminating waits, particularly of men on machines or on each other. There are many ways in which men and equipment can get out of balance, and which are hard to determine by ordinary inspection. However, time and methods studies show them up promptly.

The goal in a methods study is enough information so that the particular operation can be studied step by step, both men and machines together. Ideally, a film strip would be the best means of making such a study, with times being obtained by counting the frames consumed in covering a specific element. Several types of charts have been developed as substitutes for film strips. One is shown in the accompanying illustrations. It provides for parallel charting of the work of both men and machines.

The first step is to study the operation, in this instance loading out a cut of coal. The aim is to break it down into the proper elements and show the relationships of men and machine at all times during the cycle. When these have been plotted on the chart and the times have been added, the engineer or analyst is in position to initiate a methods revision.

ELIMINATING WAITING TIME—In the example illustrated it will be noted that there was considerable standby or waiting time in the original cycle, particularly on the part of the loader helper. How a revision might work out is shown in the second of the two charts. As a result of rearrangement of duties along obvious lines, the saving per cut is 3.72 min, meaning that output per shift should increase 18½%.

It will also be noted that even after methods revision both operator and helper have some necessary standby time. The helper in particular is standing by a total of 2.3 min even after rebalancing. Can this standby time, and the standby time of the other men in a unit crew, be put to effective use? Frequently it can—by revising the cycle with or without changes in equipment.

Consider a unit crew with duties as follows:

Loader operator and helper—conventional duties.

Bolter and helper, who also set single posts to supplement bolts.

Cutter and helper—conventional duties.

Driller and helper, who also load and shoot.

Two shuttle-car operators.

Supplyman, who also rockdusts.

Beltman, who helps with rockdusting.

Boomman.

Section electrician.

Section foreman.

Under some conditions all these men would be fully occupied. Usually, however, the helpers—and sometimes the operators—have considerable standby time. In this particular instance the standby time might be utilized by revising the crew setup and duties along the following lines:

Loader operator and helper, with the operator taking on part of the rib cleanup during shuttle-car changes and the helper setting single posts. The helper handles the cable and otherwise assists in getting the loader to the new place and started. He then returns to the previous place to spend about 5 min setting posts as necessary along each rib. He then rejoins the loader, and after the move to the next place starts, sets two safety posts at the face in preparation for the arrival of the bolter.

Bolter, now limited to bolting alone, though he may set rib posts from time to time when the loader helper is unable to complete this operation. Because the loader helper takes care of practically all setting of single posts, a helper for the bolter is unnecessary.

Cutter and helper, who also drill, load and shoot. Capacity of the mounted cutter in this instance is sufficient to permit the operator and helper to drill, using a hydraulic handheld machine powered from the cutter. Thin coal reduces the number of holes to 3 or 4. After drilling, the operator begins to move the cutter, while the helper stays behind to load and shoot, using previously prepared stemming. After shooting, the helper rejoins the operator to help with the drilling and do other work in the new place.

Three shuttle-car operators, one of whom acts as the supplyman. The extra car adds slightly to tonnage when the haul is short and facilitates keeping it up when the haul lengthens. Near the end of each cut one of the cars leaves for the supply depot at railhead and brings up posts, bolts, dummies and other materials, unloading in the place as soon as the loader leaves and before the bolter arrives.

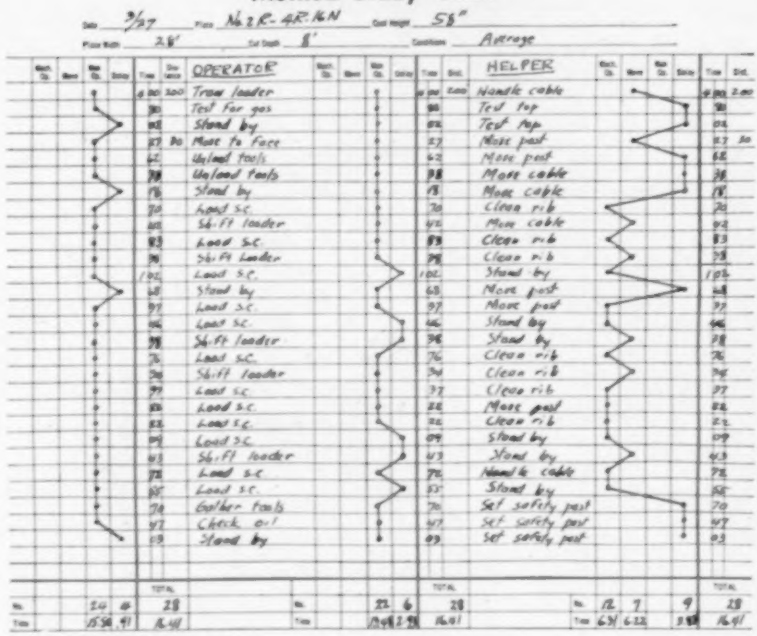
Beltman, who rockdusts and does other work when not inspecting, cleaning up and otherwise taking care of the belt conveyor.

Duties of the boomman, electrician and foreman remain the same.

Under the new setup the size of the crew is 12, compared to 15 under the old. Because of better shuttle-car service, unit output is higher.

The secret is making use of what otherwise would be idle time. Wherever a wait shows up in the operating cycle is where attention should be directed. Methods studies show up these waits and their magnitude.

Analysis of methods in this or similar

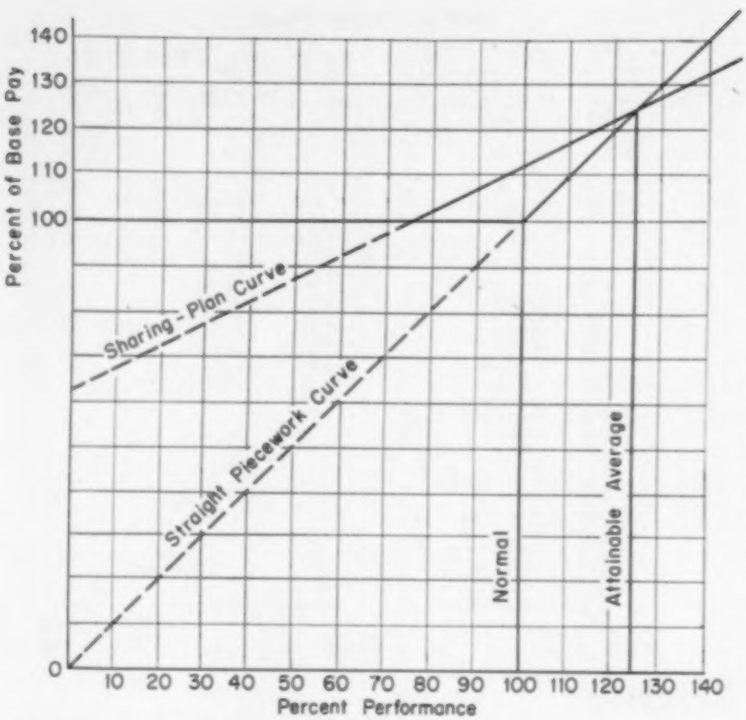


BEFORE . . .

METHODS STUDY using special chart to permit showing relationship of operator, helper and machine at all times during the cycle. The aim is to pinpoint machine and man waits as the first step in reducing or eliminating them.

AFTER . . .

HOW OBVIOUS REBALANCING of the work load between operator and helper reduces total time for loading out a cut. The cycle still contains significant waiting time, which might be further reduced by study of other unit operations.



HOW INCENTIVE PAYMENT PLANS compare at various stages of performance. The sharing plan is suggested where it is difficult to establish precise standards because of unavoidable severe fluctuations in performance.

fashion is a major step to attainment of the most efficient system, but it is not the only one. In fact, complete success is not likely to be achieved unless the charts are supplemented by check lists of questions designed to force the analyst to consider all possible ways of improvement, including, for example, number of moves, accessibility to tools, placement of controls, character and training of the man in relation to the job (Is he the right one?), and so on.

Incentive Systems

With time and methods studies providing the most efficient production setup and an accurate measure of what performance should and could be, management then is in position to adopt an incentive-pay system or systems to further enhance the benefits. The incentive plan may be limited only to supervisors, which is the common practice in coal mining, or it may, as in some instances, take in both management and men.

Incentives for foremen differ from bonuses, such as Christmas and profit-sharing, in that they are paid on definite measured performance by each individual, and thus directly reflect effort and skill. They involve (*Coal Age*, January, 1958, p 104) the establishment of definite standards for performance, proper application of the standards, controls to make sure that safety and other factors are not shortcut, and employment of capable personnel to administer the plan.

Pitfalls to be avoided in setting up an incentive plan for foremen include:

Failure to sell the plan to all levels of management.

Use of the incentive plan as a "whip" for production, rather than as a tool for helping the foreman.

Partiality in the application of standards.

Use of adjustments unwarranted by conditions.

Failure to change the standard when methods, crews, equipment or practices change. For example, if an incentive plan is to be fair to foremen and company (and to men if they are included), each section should be regularly reviewed, perhaps each week, and the bogey for the foreman and crew set in accordance with the section rating—normal, good, fair or poor, for example.

A wage incentive plan also can be used to pay workers extra money for performance above normal—in other words, for doing assigned work in less than normal time. If a wage incentive plan is adopted, an essential decision is the performance-pay relationship, or curve.

INCENTIVE-PAYMENT PLANS—A common method of payment is the hour-for-hour straight-piece-work curve, or 1% extra pay for each performance percentage point above normal, or daywork, performance. As a rule it is expected that the workers can attain an average performance of approximately 30% better than normal.

Conditions can fluctuate widely in certain occupations, including coal mining. Such fluctuations are beyond the control of the workers and, to some extent, management. Frequently, development and application of accurate time standards that reflect these variable conditions are economically impractical. A popular method of applying incentives under these conditions is to slant the performance-pay curve away from the "one-for-one" ratio toward the horizontal. The effect of such a "sharing-plan" curve in comparison with the straight piecework curve, is to pay some bonus for less than normal performance, a higher percentage of bonus for performances under the expected average incentive performance, and a lesser percentage of extra pay for performances above the expected average (see chart).

The advantage of the sharing plan is reduction of wild fluctuations in pay in comparison with, or in relation to, the unavoidable fluctuations in performance. Over a period of time the averages of pay-performance relationships should be approximately the same with both curves.

Variations of either curve are possible, and are used. The percentage bonus to be paid at attainable, or expected average, performance is a policy decision. Generally, it is somewhere between 20 and 35%, but can be set between 10 and 50%. Naturally, if the pay-performance ratio is other than 1% for 1% (0% at normal, 25% at 25% above normal), there must be a formula to convert performance to incentive pay.

Payment of 1% extra pay for each 1% extra performance (the "one-for-one" plan) results in a fixed direct labor cost per unit of output for any performance above normal. However, such a plan offers two sources of cost reduction: attaining and maintaining performance above normal; and reduction of overhead costs in relation to direct labor costs.

Under this system, the man earns incentive pay on the basis of performing the operation in a given time and not on physical output, though the volume of the latter reflects the speed with which he works. Planning and paying on the basis of time focuses attention on the key item. Thus, if 350 tons was produced by a loading unit in one section of the mine it might, in the absence of other data, be considered a good increase over the 300 tons achieved in another. Actually, however, if the necessary time-study data were available and the sec-

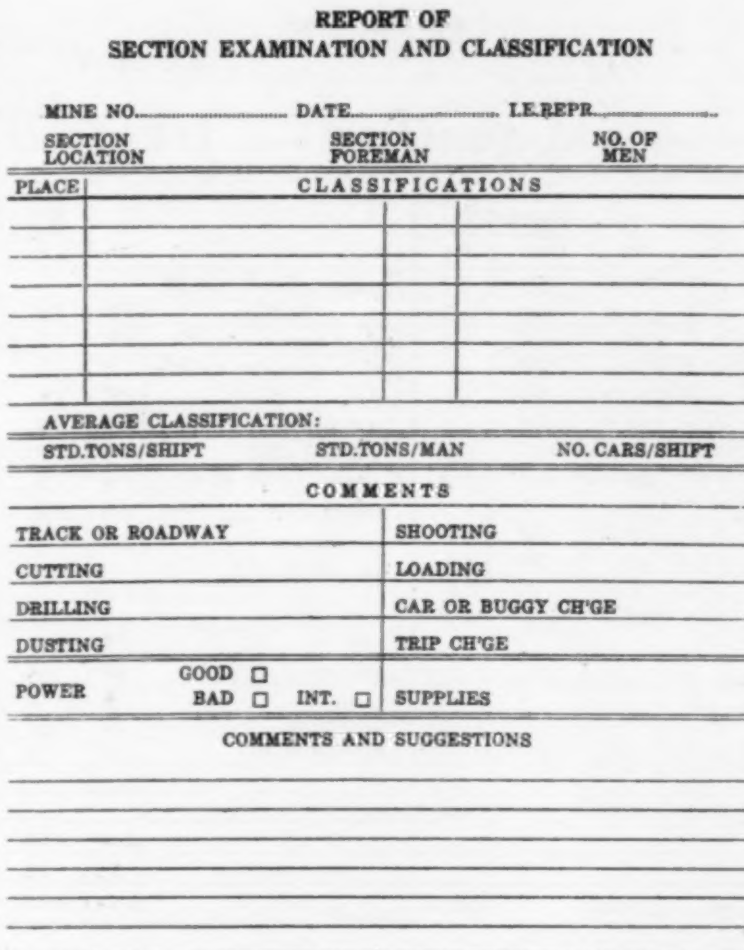
tion was properly rated to obtain the standard time per cut the picture might be considerably different. Thus, if the standard time was determined to be 33 min per cut, each cut making 30 tons, the output that should be obtained in, say, 430 min of working time is 390 tons, compared to the actual of 350.

This example brings out the basic consideration in cost control through standards—i.e., that performance is not compared with a previous output or the output of another section, which may not be an accurate benchmark, but with a carefully developed standard. Thus, a valid measure of achievement is available and control can be precise.

STANDARDS REVIEW—In coal mining major variations in conditions can occur, greatly influencing the results that are possible to achieve. Keeping pace with these changes and thus keeping the standard times used for rating performance and paying incentives realistic therefore requires that each new working section be rated and standard times set accordingly. If enough time studies are made under varying conditions, making actual time studies in new sections becomes unnecessary. Rather, the section is inspected and rated, and appropriate times or output derived from previous work ("standard data") are prescribed.

Of course, if a new machine is installed or if the system of operation is changed in any significant respect, sufficient new time studies should be made to develop realistic new standards.

The accompanying illustration shows one form of rating report which also provides an opportunity to remedy conditions that might otherwise cause undue delays, prevent the crews from reaching standard and, in consequence, up the cost.



REPORT OF
SECTION EXAMINATION AND CLASSIFICATION

MINE NO.......... DATE.......... I.E.REPR..........

SECTION LOCATION — SECTION FOREMAN — NO. OF MEN

PLACE	CLASSIFICATIONS		

AVERAGE CLASSIFICATION:

STD.TONS/SHIFT — STD.TONS/MAN — NO. CARS/SHIFT

COMMENTS

TRACK OR ROADWAY	SHOOTING
CUTTING	LOADING
DRILLING	CAR OR BUGGY CH'GE
DUSTING	TRIP CH'GE
POWER GOOD ☐ BAD ☐ INT. ☐	SUPPLIES

COMMENTS AND SUGGESTIONS

REVIEW AND RATING for the establishment of specific performance standards take the guesswork out of control and insure fairness of incentives, if paid.

Cost Control

After standards and methods have been determined, the next step is proper provisions for control. Production and delay reports are basic, and should be supplemented by budgeting and other steps for the lowest cost.

An example of how production and delay reports might be set up is shown in the accompanying illustration. In this instance columns on changing distance and standard shuttle-car wait are included for more precise control over this important phase of the face operation.

On this particular shift, if incentives were being paid on the basis of standard times, the crew would have performed 280 standard minutes of work in 245 clock min, the latter representing 480 min minus 38 min for travel and other delay time, including the shuttle-car wait. Thus, they would have earned, on the straightline basis, at a rate of 114% (280÷245). In short, the men were trying and the fact that only 13 cuts were completed, rather than 20 or more was more the fault of supervision and of management policies. These included failure to anticipate the occurrence of certain troubles, such as getting the loader stuck, and, as another example, the tolerance of cable conditions almost certain to result in delays. Had the crew, in contrast, loaded out only 11 places, it would have taken more clock time than standard time to complete the cuts, and thus the men would not have qualified for bonus pay.

This particular production and delay report shows the cost of delays in terms of dollars of expense, including fixed charges. The total assumed for this example is $1 per minute. The figure used at any particular operation would depend on the setup at that operation. In any event, showing the cost in dollars helps concentrate attention on the items that result in the greatest losses and at the same time are susceptible to correction, eliminating, of course, delays which are unavoidable, such as, travel, inspection, lubrication, etc.—though only to the extent of the standard allowed. This standard, in the case of lubrication, might be 6 min instead of the 8 shown.

The standard times, money, cost of delays and other similar data, with forms of this type, are filled in in the office, leaving to the foreman the task of recording maximum and minimum shuttle-car haul, cuts loaded out, shuttle-car change distance, and delays and delay times.

Budgeting

The budget represents the ultimate step in achievement of effective cost control. It provides an opportunity for showing, in tons of output and dollars and cents, what should be obtained

DAILY LOADER REPORT

Date 4/28 Shift 2 Section 4R 16N

Loader No. 3R Shuttle Cars Used 2

Shuttle-Car Haul: Maximum 510 Minimum 285

Tons per Room Cut 25 X Cut 22 Hdg. Cut 18

Place No.	Std. Cut Time	Shuttle-Car Change	Std. Car Wait	Delays	Min.	Cost $
R2	24.0	60	1.3	Loader stuck - soft		
R3	24.0	60	1.3	bottom	38	38
X3	19.0	60	1.3	Splice loader cable	12	12
R4	24.0	80	1.9	Splice loader cable	13	13
R5	24.0	80	1.9	Hung cut	18	18
R6	24.0	60	1.3	Car off - ramp	22	22
X6	19.0	60	1.3	Power off	9	9
R7	24.0	60	1.3	Clean face R4	14	14
X7	19.0	60	1.3	Splice conv. chain	16	16
H1	18.0	70	1.6			
XH1	19.0	70	1.6			
H2	18.0	70	1.6			
R1	24.0	110	2.5	Std. Delay Allowances:		
				Travel	38	38
				Inspection	12	12
				Lubrication	8	8
				Shuttle-Car Wait	20	20
				Normal Unavoidable	15	15
				Total	235	235
				Std. Delay Allowances	93	93
TOTAL	280.0		20.2	Loss	142	142

	Room	X	Hdg.	Total
No. Room Cuts / X Cuts / Hdg. Cuts	7	4	2	
Tons per Cut	25	22	18	
Total Tons	175	88	36	299

PRODUCTION AND DELAY REPORT shown here is based on the use of standard times and shows the money cost of delays. Comparison of performance with engineered standards insures accuracy in cost control.

after proper standards are set up, and at the same time provides an opportunity for comparing actual results with the budget goal. This makes it possible to pick up losses immediately—as frequently as every day, in fact.

Budget systems and forms naturally will vary but the principles and functions are basically identical. Assume that a mine is operating four sections two shifts a day. Two of the sections are rated at 350 tons per shift, one at 380 and one at 300. The standard crew for three is 14, and for the fourth, 12 men. This rating is based on a reasonable minimum of delays and of course on the expectation that the units will perform at the pace determined as a result of time study and methods revision.

Management has orders or the expectation of orders sufficient for a four-day schedule for the week in question. With this as the goal, the budget is worked up to provide for the normal labor, materials, power and other costs, and for certain special work to the extent that costs for the week are not seriously distorted. The budget then is set up along these lines. In this instance, it is assumed that no incentives are being paid. If they were being paid to foremen, or foremen and men, the wage totals would reflect the extra payments expected from attainment of incentive pace.

		Per Ton
Output, tons	11,040	
Section labor, 512 shifts	$11,776	$1.067
Section supplies	1,435	0.130
Roof support, 72 shifts	1,584	0.143
Timber, bolts, other	2,043	0.185
Main haulage, dumping, 40 shifts	$880	$0.080
Haulage supplies	103	0.009
Track, 10 shifts	220	0.020
Track materials	350	0.032
Pumping and drainage, 8 shifts	175	0.016
Drainage supplies	60	0.005
Ventilation, 10 shifts	220	0.020
Ventilation supplies	277	0.025
Supply handling, delivery, 20 shifts	440	0.040
Preparation, 64 shifts	1,344	0.122
Preparation supplies	760	0.069
Maintenance shop, 60 shifts	1,380	0.125
Parts and supplies	2,260	0.205
General inside, outside, 10 shifts	215	0.019
Supplies	42	0.004
Idle-day labor, 8 shifts	164	0.015
Supplies	48	0.005
Power	1,480	0.134
Power supply, 10 shifts	230	0.021
Power supplies	130	0.012
Office staff	380	0.034
Office supplies	32	0.003
Telephone, telegraph	103	0.009
Mine supervision	1,930	0.175
Outside supervision	700	0.063
Safety & inspection	320	0.029
Safety supplies	65	0.006
General and administrative	400	0.036
Special Jobs		
Complete mainline extension:		
Labor, 22 shifts	484	0.044
Materials	2,840	0.257
Start overcast, 4R 16S:		
Labor, 6 shifts	190	0.017
Materials	45	0.004
Start clearing site for new portal:		
Labor, 15 shifts	330	0.030
Materials	160	0.014
	$35,595	$3.224

The preceding is not, of course, in the sheet form an actual budget would take, nor is it presented as a typical breakdown of items. Rather it is intended only to illustrate the basic approach.

For the maximum degree of control, the weekly (or monthly) budget should be broken down into daily budgets, by section and department or activity, such as haulage or maintenance. These budgets, plus matching weekly or monthly budgets, are then given to the supervisors directly responsible as guides and standards for them. With these budgets, and with supplementary production and loss reports, such as those discussed earlier in this section, the stage is set for precise control, since the superintendent or other manager can see each day where the standards are being exceeded and, through the loss reports, the reason why. Thus remedial action can be immediate.

Budgeting can be quite precise, in spite of the variables inherent in mining. A number of companies report that they can come within 3 to 5% of actual cost in budgeting, which means that the budget is a reliable tool—the final weapon in the arsenal.

Opening and Development

COST of the plant and, especially, cost of labor are the basic reasons for care in opening and development. About $2 per ton of annual capacity is the minimum for opening and equipping a mine today, exclusive of the preparation plant and service facilities on the surface, while the average probably will range from $3 to $5. More important, an increase in labor charges for haulage, for extra travel time and in other directions, including extra maintenance of openings resulting from poor planning, can impose a large and permanent handicap on the operation.

Portal Locations

Locate, as a general rule, for lowest mining cost over life of property consistent with convenience for men and handling of coal and materials.

Consider the needs for raw- and prepared-coal storage.

Consider the possibilities of locating to facilitate present or future water connections, either directly by a plant on water or by truck, rail or overland belt from mine to barge-loading plant.

Where to Find It in . . .

The Deep-Mining Guidebook

Practice Trends

Hoisting—Slopes firmly in favor as the main opening or openings where hoisting is required.

Slope Sinking—Loaders and conveyors the major tools for belt and other moderate-pitch slopes. Rock loaders and extensible belts are new units promising substantial increase in sinking speed.

Shallow Shafts—Outlining by drilling to decrease shooting burden and shock to walls a growing practice, along with mucking and clamshells.

Big, Deep Shafts—Overshot loaders and tractor shovels powered by air or electric motors coming to the front for mucking.

Auxiliary Shafts—Drilling such shafts for handling men and supplies an increasing practice.

Mine Development—Retreat systems now practically universal in new layouts. Modifications include advance on one side and retreat on the other, retreat within panels, etc.

Number of Openings—Trend is toward an increased number where loaders are used with wheeled transportation, and to fewer where bridge conveyors and continuous miners are used.

Operating Reports

Mechanical Shaft Mucking—Overshot loader used in 37x14-ft air shaft. With 11-man crew sinking rate is 6 ft per shift. *Coal Age,* July, 1956, p 72.

Slope Sinking With Rock Loader and Extensible Belt—How this combination of equipment is used to attain rates of 4 to 10 ft per shift in 9x18-ft opening with four-man crew. *Coal Age,* November, 1956, p 68.

Drilling to Outline Shafts, Water Sealing, Simplified Lining—New drilling techniques increase depth at which outline drilling is possible. Drilling also used to facilitate grouting of both unconsolidated surface material and rock layers at low pressure with the aid of chemical additives. Special demountable form and use of boreholes speeds lining. *Coal Age,* June, 1958, p. 106.

Drift-Mine Development—Rope belts and shuttle cars serve loaders in developing two new mines in thin coal. Workings are columnized and synchronized. Separate headhouses include storage bins for coal and rock and belt facilities for rock disposal. Special provisions for handling supplies are included in portals. *Coal Age,* June, 1958, p 78.

A number of diverse factors must be studied and balanced, one against the other, in arriving at the lowest-cost location of the main opening and the main plant. Normally, if only a shaft or slope is required and the coal is level or only slightly pitching, the shaft or slope is placed as nearly in the center as possible. This keeps haulage and travel distances to the minimum over the life of the property. Normally, also, other things being equal, the opening should be made to permit hauling loads on the level or downgrade as far as possible if the dip of the coal is over, say, 1½ or 2%.

SPACE REQUIREMENTS—Space for both present and future operations should be provided in the original planning for the portal or portals. The needs include the following:

1. Space for parking as many cars as may be necessary, preferably on level or nearly level ground for easy movement when snow is encountered.
2. Space for coal storage either at the time the plant is built or at some later date. Storage facilities for as much as a week's run or more of raw or prepared coal, or both, are not uncommon nowadays, and even where capacities are more modest the trend is toward providing bin or ground space for a half to a full day's tonnage.
3. Space for expansion of the plant if desired at some future date, or for the addition of some type of equipment that might come into use at some future date.
4. Space for sludge ponds and clarification equipment if such equipment is installed when the plant is built. If not installed at that time, it should be contemplated that it might become necessary at some future date.

Availability of water for plant use if washing is done or contemplated is another factor that might affect plant location and consequently dictate a longer haul or a deeper shaft or slope to permit a more economical plant location from all standpoints, including excavation, grading and foundations. And since a surface haul normally is cheaper than underground, the availability of such a haul might in itself warrant a change from dead property center for the portal. Where an area is to be worked from several portals a surface haul or hauls to a central preparation point is the natural thing.

SEPARATING PORTAL AND PLANT—Putting the portal and the preparation plant at separate places may be the better answer to the dual problems of putting the opening at the best point for low mining costs, and the plant at a point where space is available for good design, ample coal storage, ample water supply and so on. This fact is reflected in the growing number of operations where this plan has been or is being adopted.

Location of the preparation plant completely away from the mine is a further possibility. In fact, it could be located where water, space and other necessities were plentiful, along with a wider choice of transportation facilities; for example, a combination of water and rail.

AUXILIARY PORTALS—However, moving the preparation plant away still leaves the problem of shops, parking areas and other facilities. A major question is the opening or openings for men and supplies. Unless the terrain makes it impossible or prohibitive in cost, the need for keeping travel time to a minimum has led to widespread sinking of auxiliary slopes or the opening of auxiliary portals at intervals as the mine develops to keep down underground distances for men and supplies.

WATERSIDE LOCATION—If a possibility exists that water transportation to market might become available, the reduced freight rates which it makes possible, and the competitive advantage to be gained from such reduction, warrant a careful study to make sure that either the mine portal or the preparation plant or both are located so that the mine can avail itself of the opportunity. One factor, if the mine is away from the river, is the most economical haul in relation to any

EXTENSIBLE BELT teams up with rock loader in the newest system for fast, economical slope sinking.

BIG CORING-TYPE DRILL sinks auxiliary air, man and materials shafts quickly and economically.

increase in mine cost which might be incurred. Another is a suitable site on the water for the location of the barge-loading facilities. Of course, if the coal acreage is on a navigable stream or waterway leading to a major market, the natural step is to include facilities for loading to water.

Sinking Rock Slopes

Muck with loading machines and transport on conveyors in slopes designed for belt hoisting.

Consider the possibilities of continuous miners to eliminate drilling and blasting where there is not a great deal of very hard material, such as, sandstone and limestone.

FOR SINKING SLOPES IN ROCK, where the mining company prefers to do the work itself, the following equipment, in addition to the loading, drilling and other production units, normally will be required:

Shovel, dragline or bulldozer for preliminary excavation if the material is fairly deep and soft. A bulldozer normally is required in any event for miscellaneous earth-moving and excavation, and for spreading refuse. These and certain other units frequently can be rented, rather than purchased.

Storage bin on surface unless muck is dumped directly to trucks. Normally, a bin will pay off by preventing delays and interruptions.

Refuse-disposal and service trucks.

Electrical substation or engine-generator plant.

Field shop.

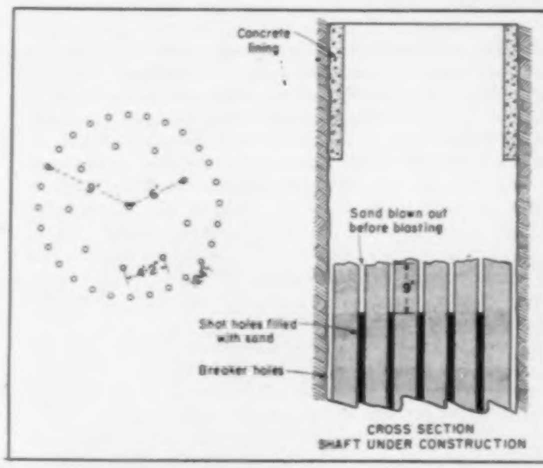
Field supply house.

Field office, locker and change facilities. These, as well as the field shop and supply house, may all be in the same structure or separate buildings may be employed, including semiportable or prefabricated. Though it is not usual practice, the permanent buildings to serve the mine throughout its life may be erected in advance of portal development.

Fan or tubing blower, with duct or tubing.

Water supply for wet drilling, sprinkling and general use.

Pumping equipment, if necessary, for dewatering slope.



OUTLINING BY DRILLING cuts cost of sinking shallow shafts by up to 50% when coupled with new grouting, mucking and lining techniques.

Concrete-mixing facilities, unless ready-mix is available at a desirable price. As an alternate to at least part of the concrete work, steel liner plate may be employed. Concreting or lining normally is done only for the softer section of material at the top of the slope. Below that, the natural-rock ribs normally will stand and the top can be taken care of by bolting or conventional timbering. Bolting also may be employed to keep ribs from sloughing or caving. Spraying with a sand-cement mixture on wire mesh also may be done to prevent spalling and disintegration as a result of temperature and moisture changes, or ribs may be coated with roof-sealing compounds.

SUPPLY-TRACK POSITION—The usual belt slope also is employed for handling men and supplies. Consequently, the belt normally is placed to one side with the track at the other and the stairs in the center. However, all other arrangements have been employed, including increasing the height of the slope and putting the belt on crossbeams over the top of

the supply track and stairs. In one instance, this double-decking was done to cut slope width in poor ground.

The belt or supply track may be separated from the other facilities in the slope by guard rails, low concrete curbs or walls, or a center line of roof supports. For easy walking, one mine built experimental steps and had men try them. As a result, the stairs were built with a 6-in rise and a 24-in tread.

Because of the length of time required in sinking the longer slopes, and also because of the long tubing runs that would be required, it may become desirable to erect a center partition, thus establishing two compartments for ventilation. Rather than use shiplap or standard brattice lumber, thin-section plywood in standard-sized sheets offers economies in both purchase cost and cost of installation.

Methods of handling heavy inflows of water from soft water-bearing measures including standard grouting and also the use of gel-type chemicals which solidify after pressure injection and render the material impervious.

Sinking Systems

Depending upon the mucking system adopted, equipment normally employed in slope sinking is as follows:

HAND MUCKING

Hoist on surface (50 to 75 hp, single drum, in most instances; same hoist may be continued in service to handle supply cars in regular operation).

Muck car.

Air compressor.

Drilling equipment. In at least one instance, a slope has been sunk using standard post-mounted electric coal augers—reportedly at a substantial saving. Normally, however, air is required in going through rock. Hand-held or other unmounted drills may be used, but their footage is lower. At the other extreme, a track-mounted jumbo—one or two drill mounts—may be employed for maximum drilling speed in slopes up to 45 to 50 deg even though it may be necessary to pull it out between rounds or provide special parking facilities near the face. Between are column- or bar-mounted drifters or sinkers, as well as newer air-leg or jack-leg units.

Roof-bolting equipment rounds out the list, unless conventional supports are employed.

CREWS AND PERFORMANCE—Minimum crew for such a sinking job probably would be approximately as follows, these men also taking care of installation of lining and roof support when not engaged in regular duties: drilling shift—two or three drillers, mechanic or electrician, and a handyman (hoisting, supplies, etc.); mucking shift—two or three muckers, hoistman, truck driver and dozer operator. It sometimes is possible for one man to take care of all hoisting and refuse disposal, although normally more than one are necessary, in which event the truck driver, dozer operator and any others employed normally will handle miscellaneous duties. And, as noted, all men will be available for installing lining, supports and the like. On this basis, average advance in a 7x15-ft slope would be 3 to 4 ft per shift—perhaps more with favorable conditions or jumbo or other high-speed drilling.

MACHINE MUCKING

Where muck is loaded mechanically, the equipment setup may be as follows:

Hoist.

Muck car or conveyor system. The latter may be chain equipment only, or a chain unit may be used between a belt unit, which eventually will become the slope conveyor, and the face. The latest addition to the group is the extensible belt. Its use is outlined later in this section.

Standard coal-loading machine, or rock loader of the standard, overshot or slusher type.

Air compressor.

Drilling equipment—substantially the same as with hand mucking. However, where crawler loaders are used and consequently cannot be hoisted out readily it may be difficult to use jumbos because of interference.

Roof-bolting equipment (unless conventional support is employed).

PITCH CONSIDERATIONS—Pitch usually dictates to a considerable extent the type of loader that may be employed. Standard or conventional loading machines usually are limited to 20 deg or less, though the overshot unit of the track-mounted type can operate on somewhat heavier inclines. With certain types of slushers, mucking can be done at up to 50 deg, other conditions being favorable.

The "helldiver," though employed mostly in coal (see following section on "Sinking Coal Slopes"), also may be adapted to sinking in rock at pitches up to 50 to 60 deg. Incidentally, where conveyors are employed to move muck the practical limits are about as follows: belt 17 to 20 deg; standard chain 30 to 35 deg; special high-flight chain conveyor designed for hoisting work, 45 to 50 deg. Where the slope is long, chains must be used in tandem, since the practical working length usually is not over 300 ft, particularly if operated up hill.

With slightly different duties, crews for machine mucking can be about the same in number as with hand mucking. Rate of sinking in a 7x15-ft slope, including lining and support, usually ranges from 5 to 10 ft per shift.

MUCKING WITH EXTENSIBLE BELT—Latest addition to the list of slope-sinking tools is the extensible belt. In combination with a rock loader at one new property (*Coal Age*, November, 1956, p 68), its use has resulted in sinking rates of 4 to 10 ft per shift in a 9x18-ft opening (before lining) on an inclination of 15 deg. The 36-in extensible unit was equipped with a special 100-ft takeup to permit tramming a safe distance back from the face before shooting. It discharged to a truck-loading bin on the surface.

The sequence of operations included drilling with telescopic leg stopers, concentrating first on bolt holes for roof support and then changing to the face. Next the holes were loaded and shot. Bolting, face drilling, loading, moving equipment back, etc., including shooting, took the four-man crew about 2½ hr. Loading was the next operation, with one man operating the loader, a second running the self-propelled tail piece of the extensible conveyor, a third acting as handyman at the face and the fourth working on the surface trucking away the rock.

Finished dimensions of the slope were 7x16 ft, achieved with a 1-ft concrete lining in part and a sand-cement coating on wire mesh on the remainder. The initial opening on the surface was made with a shovel and bulldozer, followed by installation of the concrete lining down to the solid.

CONTINUOUS SINKING

In addition to growing effectiveness in coal, continuous miners also are proving quite effective in slope sinking and other rock work where conditions are not too difficult. Equipment usually employed is as follows:

Sinking machine. To date, these have been of the boring type and have been used only in sinking belt slopes on inclinations of around 20 deg or less.

Conveyor system (muck car an alternate).

Roof-bolting equipment (unless conventional support is employed).

The use of continuous-type mining-and-loading machines for slope sinking is a relatively new development. Results so far indicate that advances of 10 to 30 ft per shift are possible, depending upon the hardness of the rock. Since hard sandstone, limestone and the like still are tough for mining-and-loading machines, they normally should be considered only where shales and other soft material predominate.

Sinking Coal Slopes

Use loading machines or continuous miners where pitch permits; where pitches are beyond those on which loaders or miners can operate, consider special units, such as, the "helldiver."

Where pitch permits, use conveyors for transportation. Special high-flight chain conveyors can operate at up to 45 to 50 deg.

EXCEPT THAT THE PRODUCT normally is not dumped to refuse, sinking slopes in coal is substantially similar in practice to sinking in rock. Equipment normally is of the coal type, and aside from loaders and the liked, may include coal cutters unless pitch, interference or other conditions prevent their use. Except for certain anthracite applications and some exceptions in bituminous mines, electric coal augers are standard for drilling, and the cycle corresponds with the cycle in a room face.

Cars or skips may be loaded by hand up to 75 to 80 deg. Conveyors may be loaded by hand up the limit of 45 to 50 deg for the special high-flight hoisting type. With loading machines, the usual limit for conveyors is around 20 deg. The maximum nose-down pitch for continuous miners still is to be determined, but they are promising candidates up to 15 to 20 deg.

SPECIAL MUCKERS—The "helldiver" is one of the special machines for fast loading in slopes up to 50 deg. It consists of a scoop on the front end of a weighted truck (for construction details, see *Coal Age*, May, 1951, p 100). With the scoop down, the helldiver is dropped into the loose coal at the face. In the hoisting phase of the cycle, the scoop is raised automatically and the entire unit is pulled to the dumping point—normally a hopper under the track with an opening between the rails. The hopper is above the haulage level and false rails permit hoisting over the level track. Coal is transferred from the hopper to cars on the level road by an elevating conveyor.

In 4½-ft coal, places 10 ft wide, with crews of 3 to 4 men, average production with the helldiver is one 7-ft-deep cut per shift, including installation of permanent roof supports and other necessary operations. With loading machines in slopes under 17 or 18 deg, 5-ft coal or thicker, the usual advance is 1 to 3 cuts per shift, with the higher figures possible as a rule only where there is little need for installing permanent supports. Advance with hand loading, whether into cars or conveyors, seldom is over one cut per shift with a 3- or 4-man crew.

Raising Slopes and Airways

Consider continuous miners for moderate pitches, and conveyor transportation up to sheet-iron pitch.

Consider big drills for parallel airways in steeper pitches.

MACHINE LOADING is as desirable in raising slopes and airways in either coal or rock up to say, 20 deg, as in sinking or production on the level. Although equipment can be installed to take cars to the face, the preferable transportation medium is the conveyor up the point where the material will run on sheet iron, which is around 30 deg. At around 35 to 40 deg, coal will begin to run on the bottom rock, and above approximately 45 deg, checks or batteries are required.

RAISING WITH CONTINUOUS MINERS—Where raising is done in coal, continuous miners have been successfully used in pitches up to 15 deg or better. In one instance, using pickup loaders, shuttle cars and cross-measure shakers for gathering, six airways were driven 1,500 ft up pitch to the outcrop by ripper-type continuous units with a substantial saving in cost over other methods. Maximum pitch encountered was 12½ deg.

In addition to raising parallel airways with conventional equipment operated from crosscuts off the main slope big drills also have been used. At one mine (*Coal Age*, May, 1951, p 100) such a drilling unit is fitted with a 42-in head, and one, two or three holes are drilled up the pitch to achieve the desired airway area. Drilling is done from crosscuts at the necessary intervals.

Shaft Sinking

Mechanize with tractor loaders for handling muck in large shafts or use special mucking machines mounted on the shaft wall or on the bottom of the cage. Consider the clamshell for mucking and hoisting in shallow shafts.

Drill to outline shallow shafts, reduce shock in shooting and facilitate mucking.

Drill outlying air shafts, supply shafts and even man and escape shafts.

SINKING METHODS may be influenced to a considerable degree by the type of shaft. Unless shafts are required rather frequently better results usually can be achieved by contracting their sinking, especially if they are large and deep, rather than by purchasing equipment and creating a staff of specialists. Surface facilities and sinking equipment, except for mucking, are substantially the same as in slope sinking, as mentioned. Lining materials, where required, include sprayed sand-cement and corrugated liner plates for circular openings, in addition to the standard timber, brick or concrete lining.

MACHINE MUCKING—Muck may be loaded into a standard sinking bucket by hand, though in a multicompartment shaft where a heavy cage can be used in one compartment, new positive-action mucking machines mounted on the cage bottom may be employed in loading the buckets (see May 1955, *Engineering and Mining Journal*, p 82, for example). Machines operating from tracks on the wall of the shaft also have been used to good effect in the metallic and nonmetallic mining industries.

Where the depth is not too great, mucking may be done by a standard crawler-mounted clamshell operating from the surface. And if access to the bottom of the shaft is possible through openings that already exist or can be driven, the muck can be dropped through a pilot drill hole into mine cars below.

Where shaft size is sufficient to accommodate them, overshot loaders or loaders of the tractor type commonly employed on the surface speed up the process of getting the shot rock into the sinking buckets for hoisting. In one instance a tractor loader, with the diesel engine replaced by an electric motor, was used to sink a 15x38-ft shaft. Capacity of the unit was 1 cu yd. The rock was shot in 8-ft-deep rounds and then the loader was lowered into the shaft for mucking operation. Eventual depth of the shaft was 430 ft, and the concrete lining was poured as each round was loaded.

OUTLINING BY DRILLING—A new technique in sinking relatively shallow shafts—under 150 to 200 ft—is outlining the shaft by drill holes, using either an overburden drill or a standard borehole machine (*Coal Age*, April, 1955, p 74; June, 1958, p 106). One company, as an example, has put down six shafts up to 160 ft deep at savings of 50% of contract prices. These savings result from a minimum of manpower, simplified excavation and a solid shaft wall that needs

a minimum of trimming, plus grouting additives to seal water off more quickly and positively.

Usual practice by the organization is to drill 8-in holes on 24-in centers on the circumference of a circle with a diameter 2 ft greater than the finished opening. Next, blastholes are drilled inside the shear holes. If the finished diameter is to be 12 ft, 10 holes are put down—one in the center and the others evenly around the 12-ft circle. The holes are filled with sand. To shoot a round, about 10 ft of sand is blown out and the holes are charged and fired. The muck is removed by a clamshell on the surface.

Cost of one such shaft was $289 per foot, as follows: drilling, $31; explosives, $8; mucking, $42; concreting, $108.

WATER SEALING—Chemical additives now increase the effectiveness of grout in sealing off water quickly and positively. In one of the previously discussed shafts, pregrouting was done with chemical additive. After the blast and shear holes were completed grouting holes 10 ft apart were drilled in a circle 10 ft out from the shear holes. Diameter to bedrock was 10 in, in which 8-in casings were cemented. The holes then were extended down to the coal at a diameter of 6 in. The tops of the casings were fitted with 3-in pipe nipples.

Grout with additive was placed in alternate holes and was forced into the strata by air from the regular drilling compressor. Ability to use such compressor equipment is one advantage of the system. On deeper holes, air sometimes may be dispensed with, since grout weight is sufficient to insure penetration.

SIMPLIFIED LINING—Pouring of concrete linings for the preceding shafts was simplified by a special demountable form spread by a roof jack and held in place by wedges and bolts. In one instance, pipes were placed in four of the shear holes to carry concrete down to the form. After each pour, the pipes were shortened 7 ft. Using ready-mixed concrete, average time for a 7-ft pour was 30 min.

DRILLED SHAFTS—Drilling is finding increasing application as a means of sinking shafts for air and emergency purposes, as well as for men and materials. These drills operate on the coring principle, with the latest employing dry oil-well-type cutters on the drilling edges. With this latter machine, the entire drilling unit is lowered into the hole, along with the operator, and is hoisted to permit removing core sections. Its initial assignment (*Coal Age*, January, 1955, p 80) was drilling a 75-in hole 467 ft for a manshaft. The hoisting equipment for this shaft, incidentally, is of the so-called friction type without a rope drum or drums.

The cost of one recent drilled shaft for ventilation at another property was $127 per foot, including $13.62 per foot for building the road to the site, grouting and other work in preparation for the main drilling job. Depth of the hole is 976 ft and the time required for the entire job, including preparation, was 6½ mo, during much of which the weather was unfavorable. Diamond-drill holes were first put down to permit pressure grouting of the strata, and surface water was sealed off by drilling a 60-in hole 40 ft deep and concreting in a 54-in casing. This opened the way for drilling of the final 48-in hole.

Rock Tunneling

Drill with modern airleg or jumbo equipment for speed and reduced labor in preparation.

Load with slushers or rock loaders.

IN STARTING a rock tunnel from the outside, it may be possible, as in slope sinking, to use a dragline or some other type of excavator to go through the soft material. At some mines, this initial cut has been left open, with the sides stabilized by planting special ground covers. Spraying with a standard sand-cement mixture also has been successfully done to stabilize cut slopes. At others, a concrete section has been installed, as in slopes, and covered with excavated material. Cut-and-cover has the advantage that the material need not be hauled away, compensating in part for the cost of the lining.

Even though not designed for such duty, coal equipment often is pressed into service where rock tunneling is a special job occurring only once in a great while. The coal equipment, of course, includes loading machines and shuttle cars and conveyors. Where much rock tunneling is required, however, special rock facilities normally are employed. Rock machines include loaders similar to coal machines but designed for rock loading; also overshot-type loaders and slushers or scrapers of the 2- or 3-drum type, the latter providing a greater degree of flexibility in covering the entire face. The machines may load into rail cars, regular or rock-type shuttle cars or conveyors. Big (15-ton or better) shuttle cars and rock loaders are a popular combination in metal and nonmetallic mining.

TUNNELING PERFORMANCE—In one 8 x 12-ft tunnel using a duckbill for loading, a crew for one shift was made up of a boss, three heading men and one loading-end man. Average performance was two rounds 6 ft deep every three shifts. Drilling time (two drifters on a bar) averaged 3½ hr per round, and loading time, 6½ hr, including temporary timbering, advancing conveyor, etc.

In an 14 x 8-ft tunnel driven with a regular rock-loading machine, average performance was two 10-ft cuts per day of four 6-hr shifts. A four-man drilling and charging crew using two post-mounted drifters normally drilled and charged 26 holes in less than a shift. The cut then was completely mucked on the next shift by a 3-man crew. A ditch 5 ft at the top, 3 ft at the bottom and 3 ft deep was mucked by a hoe-type scraper working behind the rock loader.

In an 8 x 12-ft tunnel with 2 x 1-ft ditch on one side, drilling was done by a trackmounted double-arm jumbo and a car transfer was installed to facilitate switching cars behind the rock loader. The jumbo crew consisted of four men and the loading crew of 3 men. Average advance was 1 ft per hour. At this operation two or more places permitted shifting the machines back and forth.

Mine Projection

Plan for retreat operation, either full retreat from the inside of the mine out or at least in sections or panels.

FULL-RETREAT MINING, meaning mining from the boundary back to the bottom or portal, is the ideal system, with exceptions so few as to be negligible. Before the advent of the mining-and-loading machine, or continuous miner, however, the rate of entry advance was relatively slow, even with the best of machines and systems. Therefore, complete adherence to the principle meant a rather lengthy development period during which coal production was relatively small. As a result, a number of compromises were employed to get coal out during the entry-driving period.

ADVANCE AND RETREAT—One compromise providing results frequently as good as full retreat is advance on one side of the mine or working territory and retreat on the other to complete extraction. The basic principle is followed completely if full retreat is practiced in the individual working sections, though here again rooms may be mined on one side

of a production entry on the advance, and on the other side on the retreat.

QUICK COAL—Other methods of providing coal while entries are being driven for a full or approximately full retreat system include setting off a special territory well protected by barriers near the bottom or portal, which can be mined, caved and abandoned without risk of affecting the permanent facilities. And where the coal outcrops along a hillside, quick production can be attained by moving in a shovel and stripping the outcrop, not only recovering coal in the stripping operation but also opening up the vein for augering or for deeper recovery by standard underground equipment, such as, a panel belt with loaders or continuous miners, shuttle cars and auxiliaries. If heavy rock or some other handicap makes true stripping undesirable, but conditions are such that benching is feasible and economical, augering or paneling still may be not only a help in development but also a source of considerable low-cost tonnage while the mine is getting started.

With the development of the mining-and-loading machine, the problem of going to full or near-full retreat in the thicker seams—and eventually in the thinner—is materially simplified. This results from the fact that the machine's rate of production is the same or almost the same as when working in rooms.

Contour Development

In mining hilltops and knobs, the panel belt and other modern equipment permits economical recovery at a high rate of production, whereas such areas frequently were impossible to operate when everything had to be done underground. Now, the outcrop is opened by a bulldozer or shovel —the latter normally is required to make the necessary width of bench—and the coal is mined by all-conveyor units of the hand-loaded or self-loading types; by loading machines and shuttle cars feeding to mother conveyors or panel belts; by continuous miners and extensible belts, and so on. The belts in turn may feed to mine cars on track laid on the bench. As an alternative, especially where it is desired to work sections large enough to warrant a mainline belt, the coal may be discharged to a semiportable storage bin for trucking to the main plant. By erecting the bins in multiple, it is possible to store the full output of a second shift, for example, eliminating the need for trucks and preparation facilities on that shift.

In addition to conventional equipment, contour development and production may become one of the special provinces of the remotely controlled mining-and-loading machine. Remotely controlled boring-type equipment has been or is operating at distances up to 1,000 ft from the outcrop with both articulated conveyors and the extensible belt.

Section Setups

CLOSED V. OPEN PANELS—One question in setting up a mining section is whether to aim for complete isolation: in other words, a panel completely enclosed by pillars with no openings except for the panel headings. Considerations favoring complete closing of panels include: liability of the coal to spontaneous combustion, and the possibility of breaks in the roof to water-bearing strata. Closed panels facilitate sealing and damming where fires or water breaks occur. The closed panel also facilitates sealing to comply with legislation or the rulings of inspection departments.

Pillaring within a closed panel, however, is more difficult unless conditions are more favorable than those usually encountered. Therefore pillars frequently are left in place where panels are closed, though a number of operations recover them quite successfully.

Among the benefits of the panel system, whether completely closed or open, is ease in establishing splits for each individual working section. The panel system also lends itself somewhat better to the establishment of bleeder headings—a growing practice where gas emission is heavy and even where it is not for a general improvement in conditions.

PROVIDING BLEEDERS—Bleeder openings may be established in a number of ways. Examples are:

1. In room work on the advance, driving a place from the face of the first room, when it reaches full depth, back to the return of the main or cross entry from which the room entry was turned.

2. Driving a special bleeder entry and escapeway at the tops of room panels, or between panels turned toward each other, and cutting into it by extending the room entries, or by driving over to the bleeder from the faces of the first room or rooms to be completed.

3. Extending the first rooms to be completed to cut into a bleeder opening made by leaving the pillars in at the faces of the rooms in the preceding panel. As each room is cut into the old panel, the old pillar is included in the extraction routine to complete recovery.

Pillaring Practice

A second question in setting up a mining plan is whether to take pillars or leave them. Where the coal is thin, adding to the difficulty of mining, and the top is good enough so that pillar size may be cut down to a minimum, the tendency is to leave pillars. In contrast, pillars also are left in some thick-coal areas because of bad top. Basically, however, taking pillars, unless some special conditions prevent, is desirable to get full return on the necessary expenditures for entry-driving and other development operations. Leaving a third of the coal, for example, means driving, supporting, equipping and maintaining a third more room entries for a given tonnage.

PILLAR SIZE AND SHAPE—As a general rule, these are set by experience with the top, bottom and other natural conditions in the region, with another factor whether or not recovery is immediate. Aside from the weight question, square blocks and a standard width of opening everywhere result in uniform pillaring conditions all the time, thus tending to raise efficiency. Angle driving, yielding "diamond" pillars, substitutes, as a rule, 60-deg turns for 90. Both mine cars and shuttle cars are favored by these gentler turns, but ease of operation in other directions may dictate retention of the 90-deg principle.

Changes in equipment type also influence practice in sizing pillars. Thin pillars between rooms, for example, facilitate crosscutting and pillar extraction with bridge conveyors. Otherwise, after the reach of the bridge unit is exhausted, an auxiliary cross conveyor and drive would be necessary. Even without special equipment, thin pillars may be desirable for several reasons. To get maximum extraction in first mining, as an example, one operator reduces pillars to two-cut thickness. The final recovery step is slabbing one cut off the pillar and leaving the remainder.

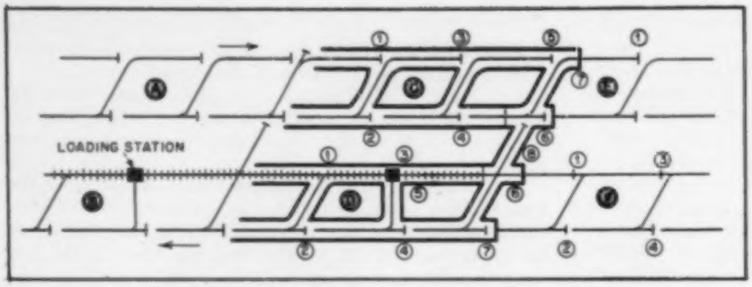
Entry Driving

After providing sufficient airway area, adjust number of openings to needs for other services and to type of equipment employed in development. With loaders and shuttle cars, for example, more is the general rule. With bridge and room conveyors, fewer is the usual rule; likewise with continuous miners regardless of the type of transportation employed.

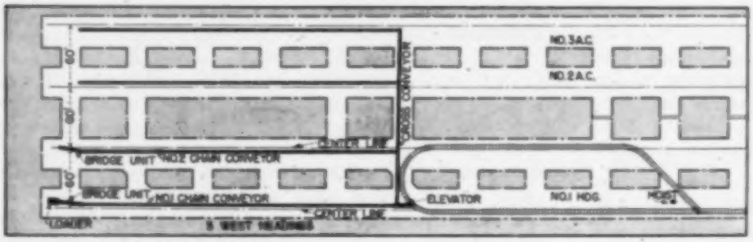
Load rock mechanically and stow in mine if possible —as close to the loading point as practicable.

NUMBER OF OPENINGS becomes possibly the first question in developing an entry-driving program. In moderate to steeply pitching coal, the difficulties of developing under

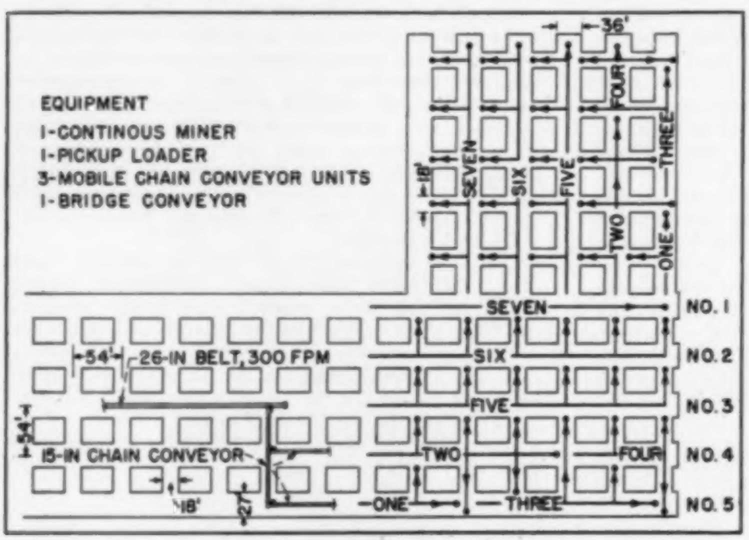
Development Planbook



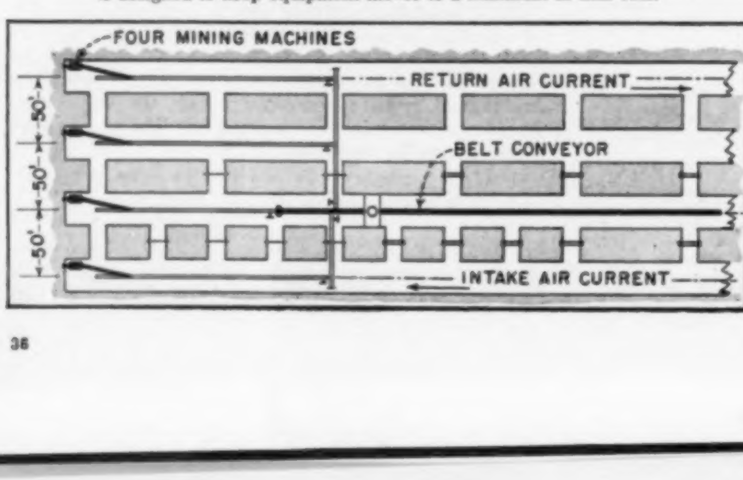
FOUR-HEADING MAIN ENTRY for development with boring-type continuous miner. Alternating from left to right the sequence of advance is shown by the letters and numbers. One objective is to keep shuttle-car tramming distance down and thus increase miner output.

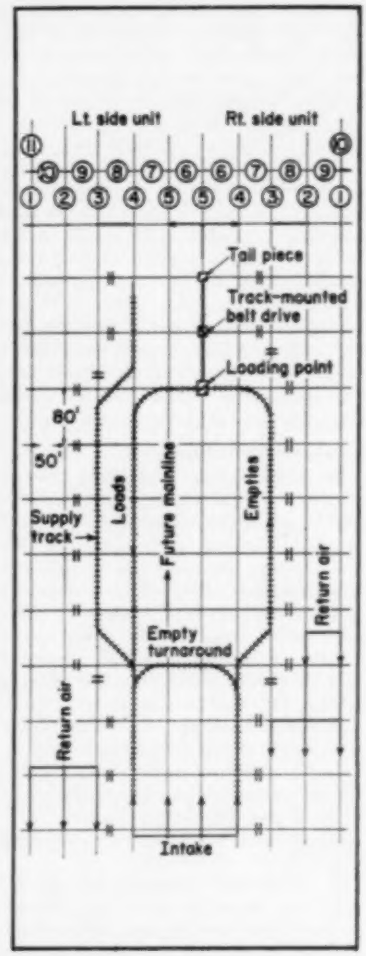


BRIDGE CONVEYOR-LOADER SETUP with loop track for cars is one of the entry-driving systems providing maximum advance with minimum cost. Cross conveyor brings coal from all four places to car-loading elevator.



MINING PLAN with continuous miner, pickup loader, bridge and chain conveyors is designed to keep equipment moves to a minimum in thin coal.





MAIN-ENTRY PLAN shows sequence of advancing headings with two continuous miners, track and belt setup, and ventilation.

ENTRY-DEVELOPMENT PLAN with auger-head miner in 36-in coal.

such conditions normally limit the number to two—a gangway for haulage and an airway above. At a fair number of collieries, gangways in coal have been given up for rock tunnels underneath the vein, though the airway still is made in the coal as a rule, with connections for ventilation and mining through rock chutes. In lighter-pitch coal, conditions are more favorable to increasing the number of openings, though the general practice still is to keep the number as close to two as possible.

The possibilities of both development and room work with continuous miners in coal under approximately 15 deg have been definitely proved in past few years. In one instance, where the inclination is 12 to 15 deg (*Coal Age*, August, 1956, p 60), ripper-type machines driving gangways and counters across the pitch discharge to shaker conveyors. Rooms are necked from the lower gangway but with the exception of every third one, driven for ventilation, are not cut through until they are needed on retreat out of the panel. The coal is transferred from the shaker on the lower side of the gangway to cars on track laid in the center after the bottom is lifted for the requisite mining height. The mining plan used at this particular operation is included in the section on continuous mining in this 1958 Mining Guidebook.

WHY MORE HEADINGS—Among the factors involved in establishing the number of headings for an entry in flat-coal mining is airway area. In the thinner seams, especially if the air volume is expected to be large, driving additional openings to keep down velocity yields substantial savings throughout the life of the mine. But even after all the necessary openings for haulage, ventilation and man travel have been provided, it still may be desirable to increase the number. This is especially true with loading machines, and to a lesser extent with certain other equipment. The goal in increasing the number of headings is to make development work as near like room work as possible, which means the lowest cost.

WHY FEWER HEADINGS—The continuous miner and the bridge conveyor, among other new devices, are reducing the need for increasing number of headings for the sake of lowest face cost. A loader in two places equipped with bridge conveyors, for example, often can achieve higher tons per machine and per man, and thus a lower cost, than the same machine with conventional transportation in a considerably large number of places.

With continuous miners, the case is even more pointed. Such a machine, in effect, doesn't care whether the opening is a heading or a room. Therefore, it is not oversimplifying things to say that the production and the cost are the same. Consequently, there usually is no need to increase number of headings to enable the machine to do better, though the number may be increased for other reasons.

ENTRY-DRIVING SETUPS—Equipment for entry driving in coal normally is the same in type and general method of use as in other coal work. With mine cars or shuttle cars, any convenient layout for track or transfer stations may be employed.

An example of an entry-driving plan with four headings is shown in an accompanying illustration (*Coal Age*, February, 1957, p 78). In this instance, the mining unit is a boring-type machine served by three shuttle cars, one a surge unit. Heading advancement is in a definite sequence, as shown by the letters and numbers. The basic plan is to advance the headings in pairs to keep tramming time to a minimum and also keep to a minimum the number of crosscuts in the center pillar.

Another operation using ripper-type machines provides an example of a large number of headings in entry development, to wit: nine for mains. Two machines work in the entry, each being assigned four headings on each side. The center is worked by one or the other machine, depending upon the rate of advance. Using the center as the extra place simplifies keeping the two units abreast. The crew consists of two facemen, whose duties include placing screw jacks under temporary face crossbars, extending curtains, rockdusting and shoveling loose coal to the center of the place; miner operator; pickup loader operator; two shuttle-car operators; utility man; ventilation man, who helps rockdust; one roof-bolter; and one electrician. Average machine output in 55-in coal is 400 tons (raw) per shift.

A ten-heading plan for two continuous machines is shown in an accompanying diagram. In this instance, the crosscuts between the two center headings serve as the equalizers.

With conveyors, whether loaded by hand or machine, some form of cross unit normally is necessary to bring the coal to one point, for transfer either to a mother belt or mine cars. One layout, based on bridge conveyors (*Coal Age*, September, 1954, p 106), is shown in the accompanying diagram. The cross conveyor brings all the coal to an elevator. Cars are loaded in trips on a loop track, with movement by a hoist.

A second conveyor layout illustrated shows a belt for panel haulage instead of cars.

Instead of the loop track, tail tracks for pushing in and pulling out are common in receiving coal for both conveyors and shuttle cars. Frequently, to get the necessary length of tail section, it is turned into a room or through a crosscut, with the elevator on the curve.

Keeping equipment moves to a minimum was one goal in another plan for boring-type continuous miners shown in an accompanying illustration. Arrows and legends show the sequence of advance. Rooms also are driven in similar fashion.

CROSSCUTTING ON PITCHES—The making of crosscuts between gangways and airways is one of the most costly and aggravating operations in developing for pitch mining. The big drill—36 or 42 in, or larger—has been suggested and used for this purpose (*Coal Age*, May, 1951, p 100). A new unit (*Coal Age*, August, 1955, p 58) is designed for pulling the big bit by a wire rope through a pilot hole, thus decreasing drill size and also weight to a few hundred pounds. One advantage of drilled crosscuts is the fact that they are small, though still large enough to carry the required volume of air. Consequently, they can be closed with a simple wood or steel disk, rather than an expensive custom-made stopping.

Rock Handling

Where taking rock is a matter of brushing top or lifting bottom in a haulage road, as distinguished from regular tunneling, the tendency is to use coal equipment to save the cost and complications involved in employing special equipment. General practice is to alternate with coal and rock cuts, whether in the top or the bottom. Other operators, however, drive in coal various distances, usually from one crosscut to the next, or some other fixed distance—100 or 150 ft for example—before taking top or lifting bottom. This is facilitated by the use of rubber-tired haulage units.

MINE DISPOSAL—A balancing of all the factors may result in a decision to haul all the rock made in attaining height to the outside for disposal. However, disposal in the mine avoids the haul outside and the supplementary operation of throwing it away on the surface. Some of the methods adopted for underground disposal are: (1) stowing along the rib where the opening can be made wide enough for this purpose; (2) stowing in crosscuts; (3) stowing in openings made especially for the purpose—for example, stubs driven into barrier pillars; (4) stowing in special gobbing rooms or back entries. At one anthracite operation in light-pitch coal, as an example of the latter, a lower "water gangway" receives rock from a cross conveyor laid through the crosscuts (*Coal Age*, July, 1955, p 74). In flat coal, the fact that the shuttle car is not limited to one opening or route makes it especially useful in stowing in crosscuts or special stubs, rooms or entries.

Continuous Mining

SUCCESS with continuous mining, like success with machine loading and other forms of mining, requires that stress first be laid on what goes on before and behind the machine. After that, attention can be paid to the way the machine is operated, and particularly to the way it is checked, lubricated and maintained.

Ten of the prerequisites to successful mining are summarized on p 21 of this issue. In addition, some of the things requiring particular attention in continuous mining are as follows:

1. **Development of a Suitable Mining System.** Mobile-type continuous machines in the United States are designed for use in room-and-pillar systems, and work quite successfully in such systems. Widths, centers and the like, however should be modified, if possible, to conform to the characteristics of the machine selected. The trend apparently is toward 90-deg work and complete pillar extraction though a fair number of angle plans or mixed square and angle plans are employed.

2. **Roof Support Without Hindering Production.** Bolting units on miners are one answer. Alternating places, or alternating lifts in a place with rigid-head units, to permit timber advance in stages of, say, 20 to 25 ft, are others.

3. **Adequate Ventilation.** Because speed of advance increases gas emission and dust formation, positive means must be employed—brattice lines, auxiliary fans, etc.—to keep the face clear and gas and dust below the hazard levels. Yet too much air results in discomfort. Spraying and rock-dusting become much more important. Also, as a result of higher gas and dust formation, care must be taken to insure good rockdusting in return airways. New types of filters, incidentally, offer the possibility of trapping the dust as it is made in an economical unit that would not be unduly bulky.

Practice Trends

New boring, ripping and cutting units providing both increased capacity and ability to mine the thinner seams, thus substantially widening the field of application of continuous equipment.

Shortwall and planer-type mining-and-loading units growing in thin coal, and are being joined by new low-type mobile machines, thus giving the low-vein operator a much wider choice of equipment.

Conveyor transportation with bridge and extensible units growing rapidly.

Full retreat in panels more common with advance on one side and retreat on the other equally popular. Bleeder openings incorporated in practically all plans. Right-angle or 90-deg plans most common even with fixed-head or semi-rigid continuous miners. Pillaring scheduled for almost all continuous mining setups, with open ending a fairly popular system.

Production with ripper-type continuous units proved feasible in two bituminous operations with pitches up to 15 deg.

Future Possibilities

Level Coal

A major expansion in the use of remotely controlled boring-type miners, reflecting in part design of control units for application underground. These, in low-height designs, may be one answer to the problem of continuous mining in coal under 3 ft in thickness.

Pitching Coal

More use of continuous machines in light-pitch coal after development methods are changed to accommodate them; more longwalling in light pitch with longwall-type continuous miners; more development of special machines, such as the funnel-head miner.

Continuous Systems

Match mining plans to machine characteristics as closely as possible, but particularly to the type of transportation equipment employed.

Be prepared to change plans to take advantage of new types of transportation equipment, including those that are still only ideas or have not yet been thought of.

Plan to get all the coal, which means pillaring if reasonably possible.

Continuous mining is now in the stage of reliable production at relatively high rates. Consequently, the possibilities and limitations are relatively clear. One result is that it is more apparent that continuous mining is not the answer to every problem, though it normally results in a substantial cost decrease.

This accounts for one mine now limiting continuous units largely to entry driving, one reason being that their reach makes them more suitable for narrow places, whereas conventional equipment can better cover the wider faces encountered in room work. There are other reasons for limiting continuous machines to certain areas or for taking them out completely and going back to conventional units. One is the presence of thick

bands or a number of thin hard partings. Another is heavy pyrites intrusions, running up bit cost. However, in the normal course of things, miners must be prepared to tackle a moderate amount of material other than coal, and the majority do fairly well—at the price of some temporary increase in bit cost.

MOBILE MACHINES EMPHASIZED—As with earlier mining equipment, the emphasis in the United States has been on mobile machines, even though the actual mining principle ranges from ripping to boring. As a result, most of the continuous production comes from room-and-pillar or block systems, modified as necessary to take fuller advantage of the potentialities of the miner—and more recently of the new types of conveyors.

The mobile design of practically all mining-and-loading, or "continuous," machines used in the United States and Canada has resulted in projections very similar, for the most part, to those previously employed for conventional loading and, earlier, for hand loading. Certain exceptions, used with special equipment, such as the planer, are discussed in the "Longwall" section of this article.

Even though the plans are generally the same, mining with continuous units differs basically from mining with earlier equipment in that the continuous machine can stay in one place, compared to loaders, for example, and can produce "continuously" from that place, compared to the intermittent production from, say, conveyor places, where the need for cutting, drilling and shooting, even though overlapped with each other and with loading as far as possible, necessarily cannot be arranged so that loading is continuous.

This ability of the continuous miner to get all its tonnage from a single place has, among other things, eased the problems of entry-driving and development in at least some respects, as outlined in the previous section on opening and development.

CONCENTRATION POSSIBILITIES—Continuous equipment also provides an opportunity for a concentration of production previously impossible to attain. As an extreme example, all the machines necessary for the desired output per shift may be stationed in adjoining places, and the places may be either rooms or entry headings with no significant difference in output, other things being equal. One bar to heavy concentrations, however, might be the corresponding increase in the rate of gas liberation, which might make it difficult to get enough air to the points of coal production to keep the percentage below safe limits at all times. High concentration also may add to the difficulties of providing continuous haulage, handling men and supplies, rock-dusting and so on.

With conventional forms of transportation, such as, shuttle cars or standard room conveyors, "room" depth necessarily is much the same as with conventional equipment. New transportation units, on the other hand, such as, the articulated and extensible belts, permit changing projections to provide for "room" lengths up to 1,000 ft. Thus, along with the fact that the continuous unit simplifies the entry-driving phase of development, even fewer entries are necessary with the long rooms.

Examples of current systems for various types of miners, haulage equipment and conditions are summarized in the "Continuous Mining Planbook" at the end of this section. A supplementary planbook shows various methods of mining individual pillars with continuous machines. Most of these pillaring plans also lend themselves to use with conventional loading units.

TOP BENCHING—Coal over, say, 9 to 10 ft in thickness has always presented a problem in pillaring, whether loading was done by hand, by loading machine, or by continuous miner. All the earlier systems, involving driving rooms

Operating Reports

Boring-Type Units—Six machines making openings 13 ft 2 in wide and 7 ft high average 458 tons of clean coal per shift. Panels now designed for rope-type extensible belts. Rooms driven in pairs and pillars mined by pocketing on 45 deg. *Coal Age*, February, 1957, p 76.

Pillaring With Continuous Machines—Panels laid out for loop haulage, main-entry pillars recovered in final extraction, individual pillars recovered open-ended. *Coal Age*, March, 1957, p 58.

Western Pennsylvania Practice—How one type of miner is used to develop places and mine pillars in seven operations, including recovery of standing pillars in old sections. Average raw output per shift, 190 tons; minimum, 155; maximum, 240. Average tons per man, 45; average reduction in face labor, 52.5%. *Coal Age*, April, 1957, p 70.

Preparing for Continuous Mining—Machine selection, mining plan, roof support, ventilation, power, coal haulage, manpower, supplies, maintenance, effects on preparation. *Coal Age*, May, 1957, p 77.

Development With Continuous Units—Two ripper-type machines advance nine headings abreast and average of 750 ft per month, two shifts, 55-in average thickness. Pickup loaders and shuttle cars deliver to belts. *Coal Age*, May, 1957, p 84.

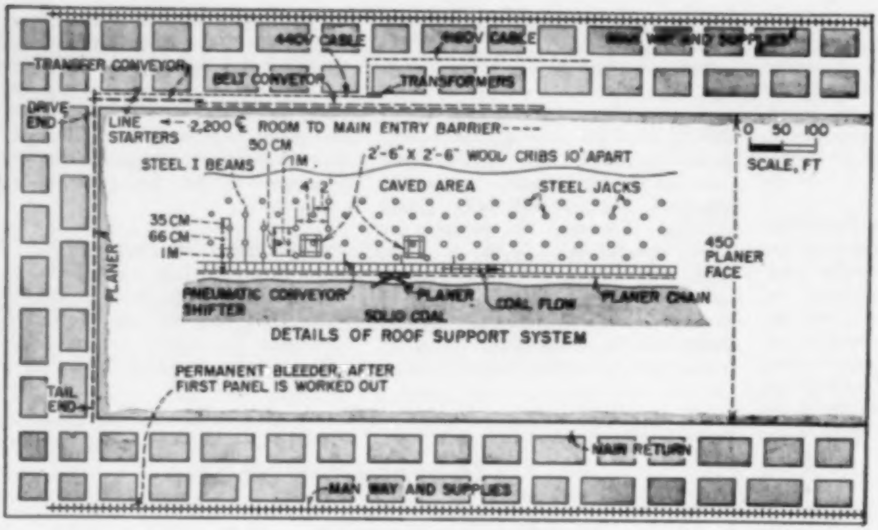
Boring Units With Bridge Conveyors—Served by mother belts, room-type chain conveyors and bridge units, boring-type miners advance headings and room groups in sequence designed to keep equipment moves to a minimum. Average output in 42- to 48-in coal is 53 tons per crewman. *Coal Age*, August, 1957, p 62.

Pillar-Mining Projections—Varying plans for varying seam thicknesses and conditions, with ripper, semirigid and boring-type miners, employ alternate right-and-left and conventional pillar-recovery methods. *Coal Age*, January, 1958, p 92.

Funnel-Head Miner—Developed in Canada particularly for pitching coal, new unit includes bridge conveyor and can be used to set crossbars. *Coal Age*, January, 1958, p 122.

Slabbing After Mining—Boring machines with rope-type extensible belts first mine rooms in 6-ft coal to depths of 600 ft. Crosscuts are made on 300-ft centers with booster fans for ventilation. After miner drives full depth, ribs are center-cut to depth of 11 ft. The coal is then shot and picked up by conventional loader. *Coal Age*, February, 1957, p 124.

Twin-Unit Development—Two ripper-type miners with pickup loaders and shuttle cars work together in advancing 10-heading entries. Crosscuts between center headings serve as the equalizers. Room panels feature bleeders and complete pillar extraction. *Coal Age*, April, 1958, p 86.



COAL-PLANER SETUP in 40-in coal, 450-ft face, collapsible steel jacks, headers and cribs for roof control.

and crosscuts on the bottom and then working up resulted in trouble and loss of coal, not to mention the extra hazard to personnel.

With the advent of roof-bolting, top-benching with both loaders and continuous miners has become increasingly the practice in thick coal. Development is the same as in the past, except that it is done next to the roof instead of along the bottom. This permits securing the roof by bolts and eliminates the need for long posts and heavy collars, which normally are inadequate for the job. After the rooms and crosscuts are driven in the top, the bottom coal is removed by ramping down in the rooms and also in the open-end or split places in the pillars.

PITCHING COAL—With some variations depending upon machine type and natural conditions, standard continuous miners can work up and down pitches of up to approximately 20 deg. Entries naturally are driven on the level and rooms are turned up pitch in usual fashion, except for perhaps some modification in centers to facilitate pillaring, if done. Of course, if the continuous miner is limited to entry-driving alone it can be used in coal pitching up to 90 deg. A new funnel-head machine has been specifically designed for such conditions (*Coal Age*, January, 1958, p 122).

Suggested plans for using continuous miners in coal pitching more than, say, 20 deg, include driving long places across the strike, using an extensible belt, and then drilling and shooting the up-pitch pillar, starting at the inby end of the place and using the miner as a loader in picking up the coal if it is of the type equipped with loading arms. Otherwise, a standard loader could be brought in for this phase of the work.

Longwall

Consider for very-thin or moderately pitching seams.

ROOF CONTROL is the heart of longwall mining and requires not only special support systems but also considerable specialized experience, compared to the conventional room-and-pillar system. Also, the usual type of equipment designed for room-and-pillar and properly operated gives such a good account of itself that longwall finds it difficult to compete in the thicker, flat seams.

For these and other reasons, longwall in the United States and Canada is so far limited to thin or pitching coal, as a rule. Also it is largely limited to special types of equipment, such as, the stripper or planer, or special ripper equipment operating open-ended.

LONGWALL PLANS—An example of a longwall face designed for planer mining is shown in an accompanying illustration (*Coal Age*, May 1956, p 72). Face length is 450 ft and average production per shift in 40-in coal is 500 tons, with the maximum 1,000 tons. The aim in roof control is to cave the top behind while keeping the face open with collapsible steel jacks, headers and cribs.

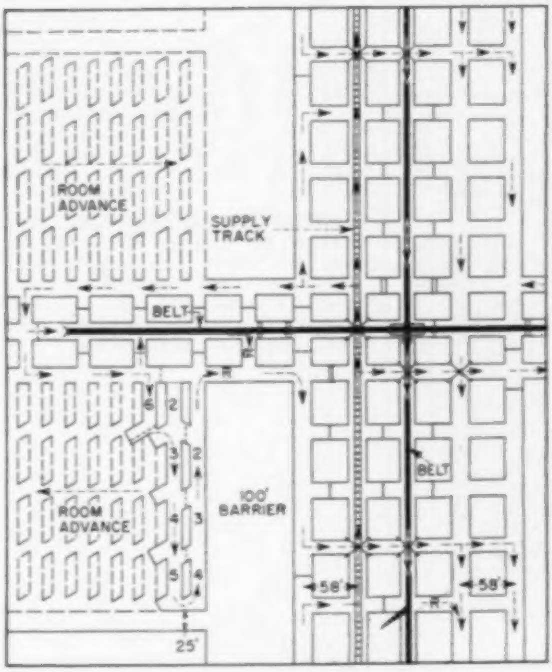
A face designed for a ripper-type longwall unit under heavy cover in Canada (*Coal Age*, December, 1953, p 84) is operated with packwalls. The walls are established up and down the pitch and the miners operate on pitches up to 18 deg. Length of a wall is approximately 500 ft, or no more than a machine can clean up in a shift. This is necessary because conditions are such that all supplementary work—advancement of conveyor, packwalls and face support—must be done on the offshift, and failure to complete the cut would mean losing a day in the production cycle. On light pitches the machines cut both ways. On heavier pitches, it cuts downhill only and is trammed back to the top of the wall on the offshift.

Originally, the miner discharged to a belt conveyor alongside. "Python"-type flexible chain conveyors are being substituted for the belts, and are pulled over by the miner itself as it returns to the top of the wall in the heavier pitches, thus releasing a conveyor-moving crew of 8 men for other productive work. An incidental benefit is an increase in wall production by eliminating the spillage encountered with belts. On longer walls, this runs to 30 to 40 tons per shift.

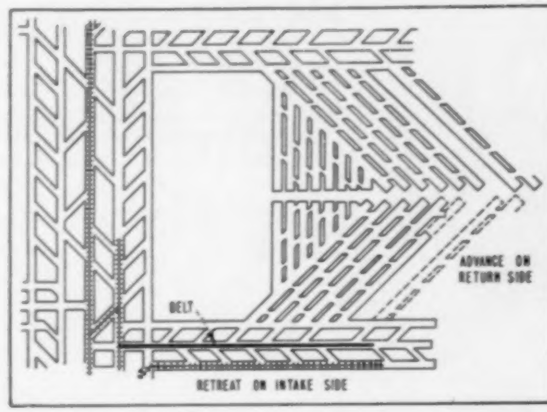
ROOF SUPPORT—Theoretically, longwall provides the maximum in continuity of production, but roof control normally requires more support and more labor to install it, in addition to other special requirements and facilities. Thus, as noted, it finds it difficult to compete with conventional equipment in thick, flat coal. However, particularly where thinness or pitch prevent the use of conventional equipment, the continuity of production with longwall methods and modern longwall units normally—though not always—more than offsets the cost of extra support and facilities, with resultant significant increase in tons per man. Thus, one planer in 3-ft coal has raised output per man-shift to the parting 2 to 4 tons compared to production with conventional methods, while the ripper-type pitch unit has gone over 600 tons in a mining shift with tons per man to the car-loading station, loading shift only, of over 50. Average mining height is approximately 4½ ft.

Continuous-Mining Planbook

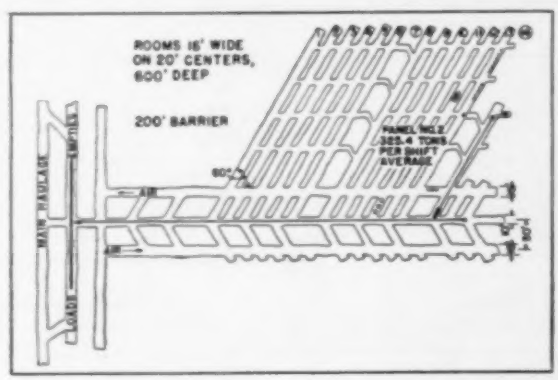
Room Plans



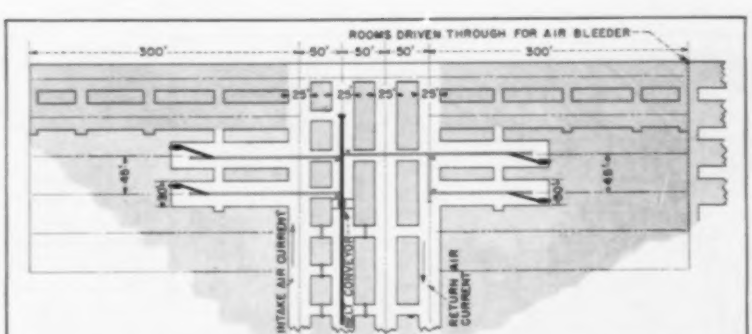
ADVANCE ON ONE SIDE of the panel and retreat on the other distinguishes this room plan for ripper-type units. The mining sequence in the first two rooms establishes the cross-cutting pattern for subsequent places.



ANGLE PLAN with shuttle-car and belt haulage. Rooms are worked advancing on the return and retreat on the intake. Stub rooms are driven to mine the triangle formed in this project.

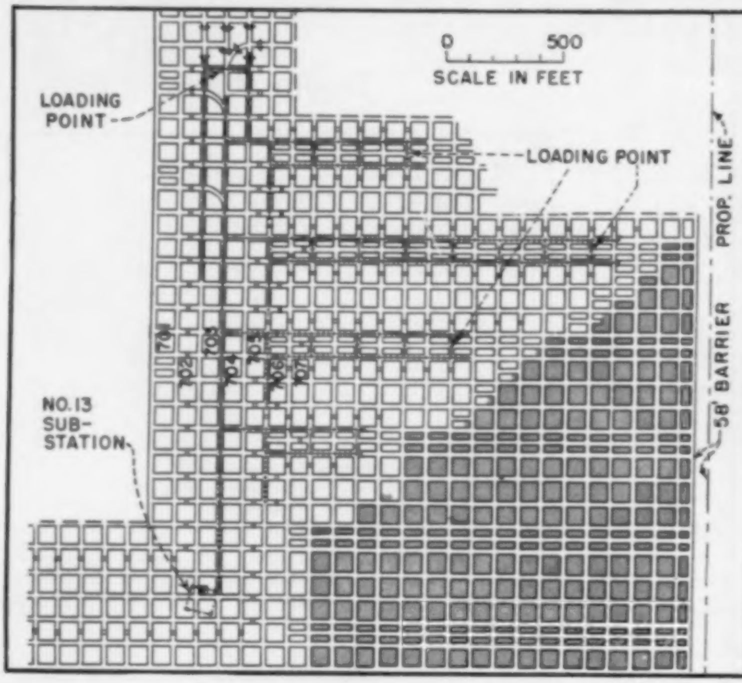


ANGLE PLAN with haulage by extensible belt, advance on one side and retreat on the other, ripper-type machines. Rooms are 600 ft deep.

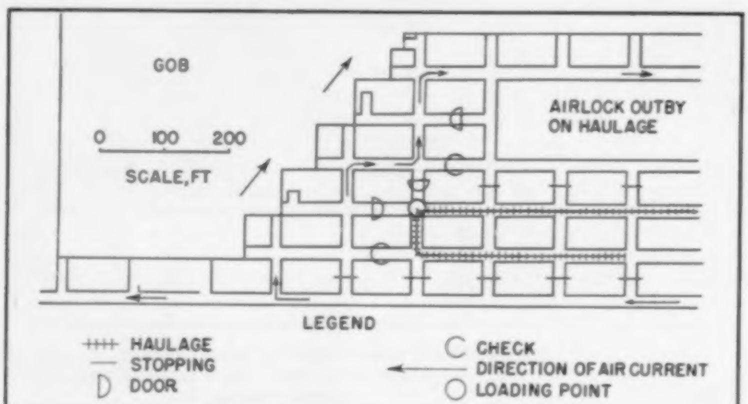


PLAN FOR AUGER-HEAD MINER shows full retreat after entry development. Machines on each side discharge to bridge and room conveyors. To increase recovery, rooms may be slabbed on the retreat.

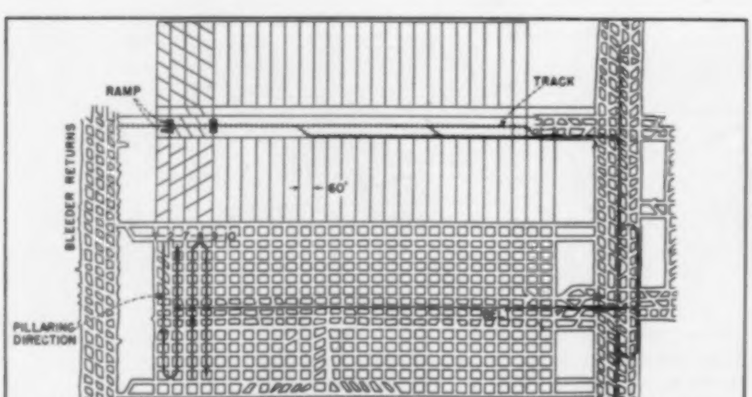
Pillaring Systems



STEPPED PILLAR LINE—Long pillar lines are the exception rather than the rule, and where used frequently are stepped, as in this plan, each step constituting a section for a ripper-type unit. Loop-haulage system eliminates car-change delays at loading points.

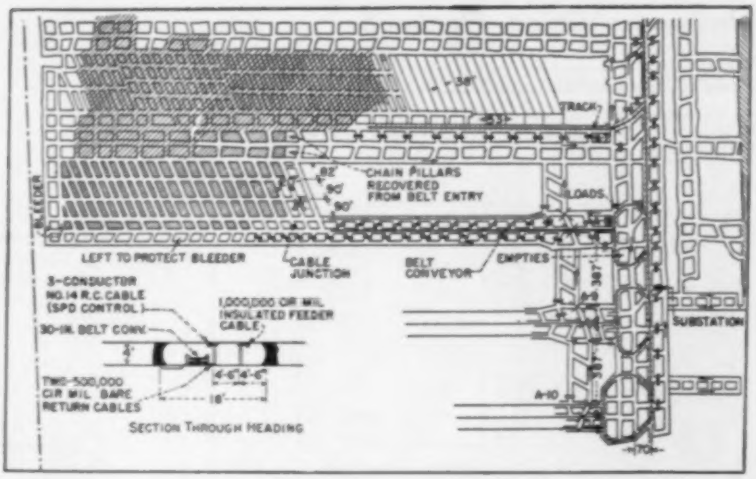


"SHORT-ROOM" PLAN for semirigid head machines employs rectangular pillars. There is little basic difference between development and room work in this system. Loop track facilitates haulage from shuttle cars.

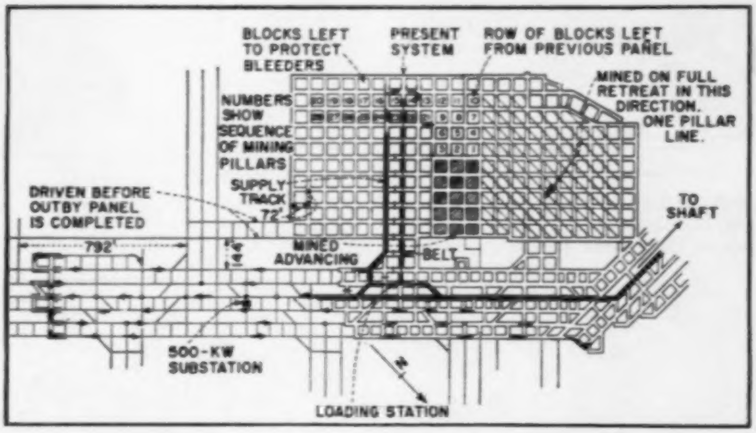


CRISSCROSS PILLAR EXTRACTION features these setups for operation with boring-type miners and belt or rail transportation. Like many other systems it features bleeders, including a special bleeder at the tops of the panels.

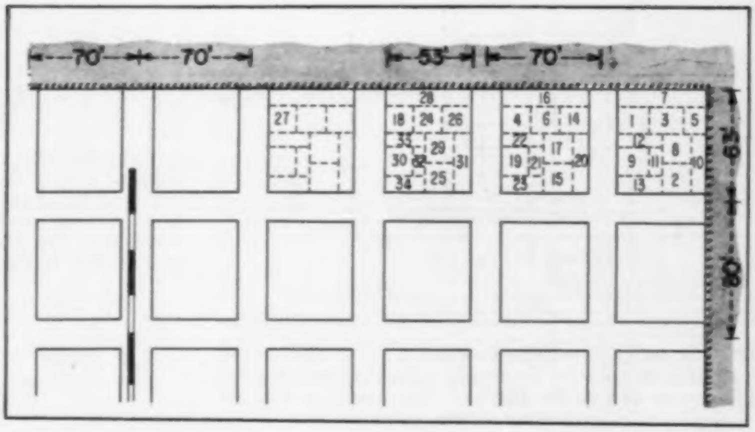
ANGLE DEVELOPMENT with rooms on only one side of the panel features this retreat-mining plan for boring-type miners in medium-thickness coal. The miner changes from one place to the next of two each time it reaches a crosscut. Thin pillars are mined open-ended when a room is completed.

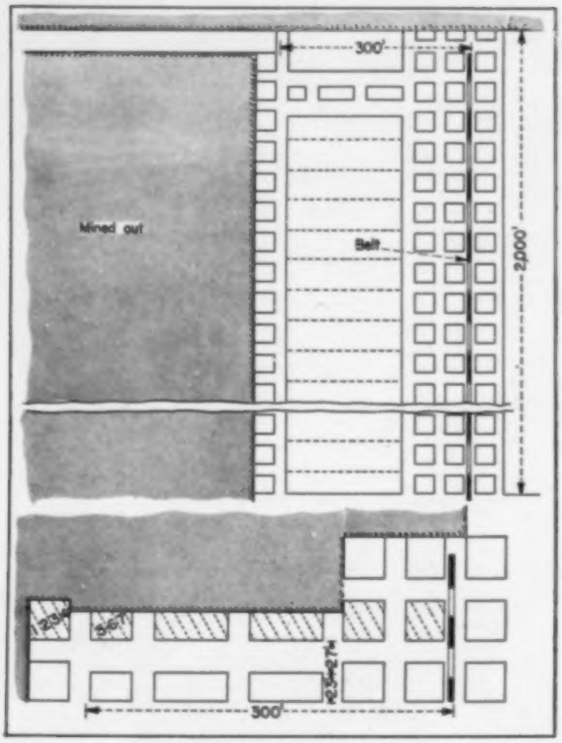


ADVANCE ON ONE SIDE OF THE PANEL and retreat on the other features this plan designed for a minimum of open territory. Two rooms are always kept open ahead of the advancing pillar line by driving a new place as soon as each line of pillars is completed.

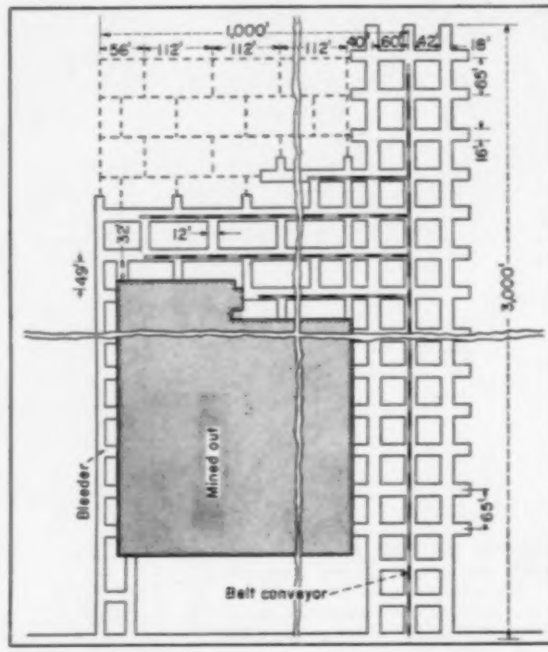


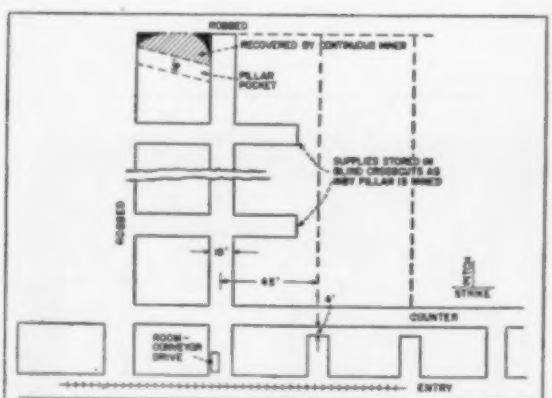
BARRIER RECOVERY PLAN (barriers 500 to 700 ft thick) with semirigid machine. The rectangular blocks are mined from two sides in the sequence shown.



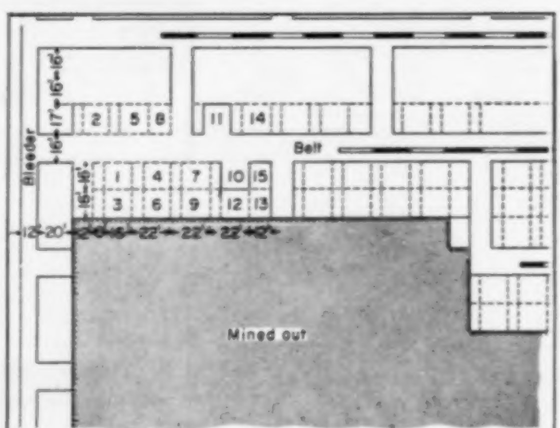


ANGLE-PILLARING PLAN for boring-type miners in 40-in coal. The first two rooms are driven abreast to establish ventilation. Then rooms are driven and pillars are mined on the angle as shown.



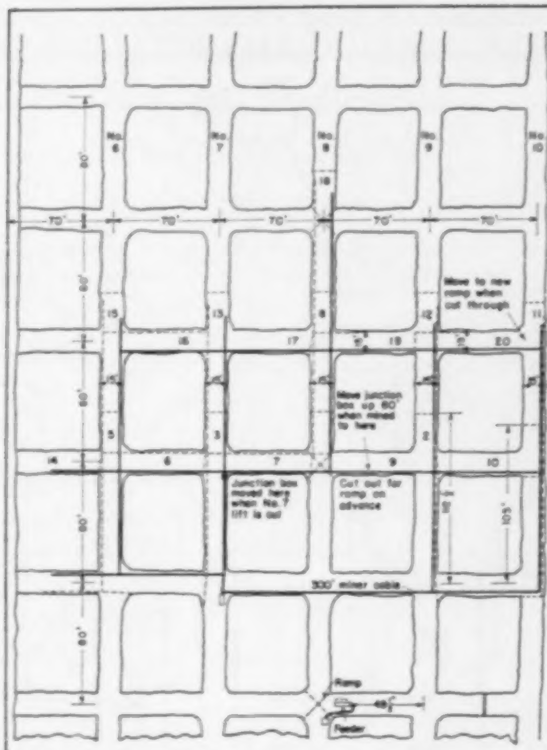


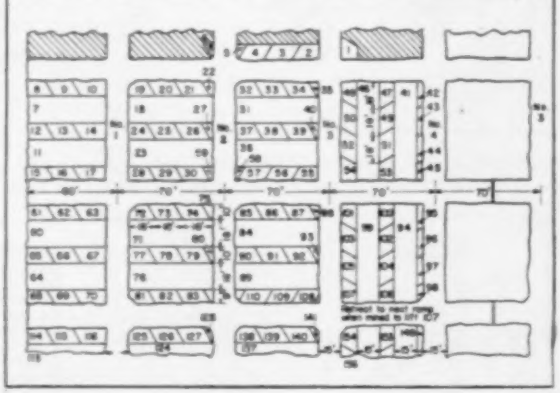
PITCH PLAN for ripper-type machines in 12- to 15-deg work. Blind crosscuts are used for supply storage. Conveyors bring coal down to cars on the gangway. The counter is used for miner travel.



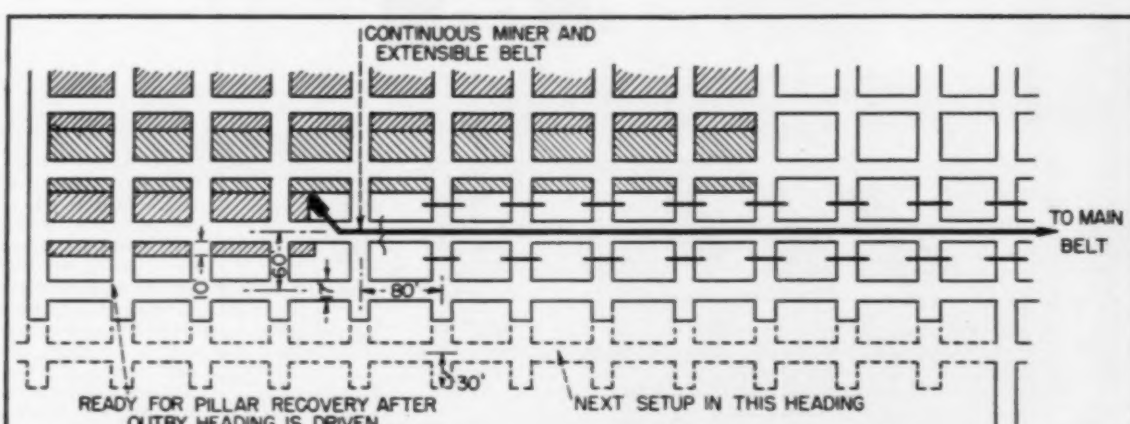
RIPPER-MACHINE PLAN for 66-in coal, sections 2,000 ft wide and 3,000 ft deep, mined advance and retreat. Alternate right- and left-hand pillar extraction is practiced, with pockets driven as in the view below to complete recovery. The miners discharge to extensible belts equipped with bridge conveyor. Coal recovery is about 90%, and good pillar falls are secured.

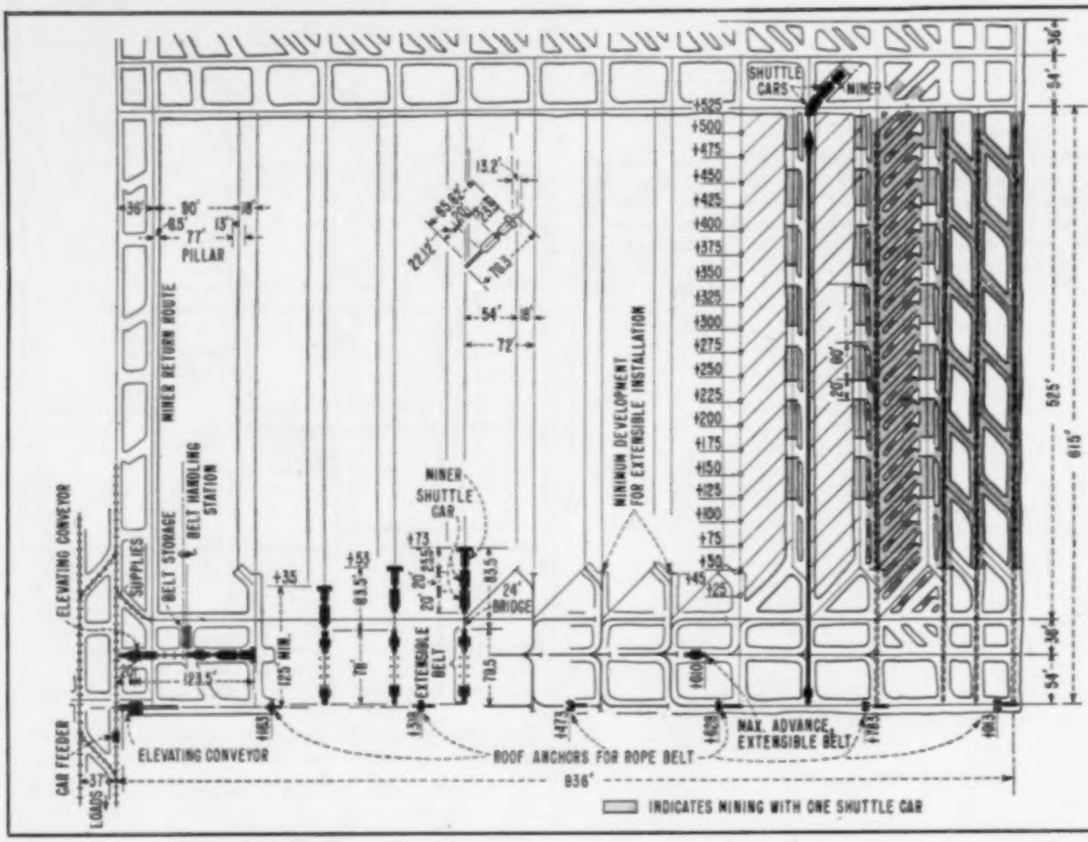
KEEPING EQUIPMENT MOVES DOWN was a major objective in this mining plan for thick coal and ripper-type machines with shuttle-car service. Strict adherence to driving sequence limits equipment moves. Pillars are removed one at a time by 18-ft lifts leaving 10-ft fenders. Bolting units are mounted on the miners. Average output is 43.6 tons of clean coal per faceman.



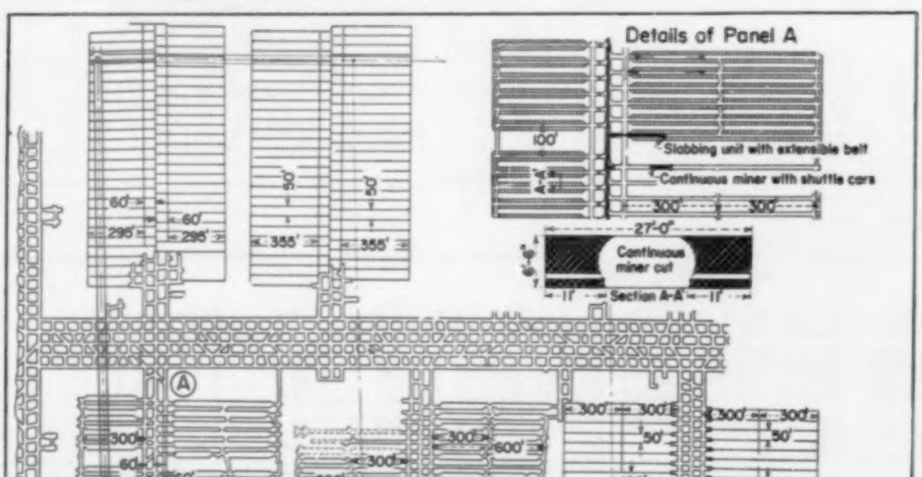


EXTENSIBLE BELT PLAN for ripper-type miners permits driving places 1,000 ft deep. When the place is driven the miner takes 10 ft off the pillar on the solid side and then completes the pillar on the gob side. When extraction is completed, the miner leapfrogs the next place (already driven) and drives up the third one. Miner and head and tail sections of the belt then return to complete No. 2, in which extra belt and stands are in place.



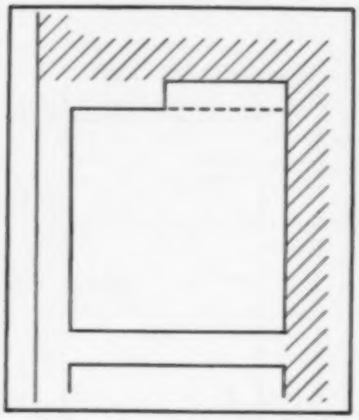


MINING WITH BORING-TYPE UNIT and rope-type belt in 525-ft rooms, thick coal. Pairs of rooms are driven on short centers and pillars between pairs are mined by angle lifts. Chain pillars are recovered with two shuttle cars.

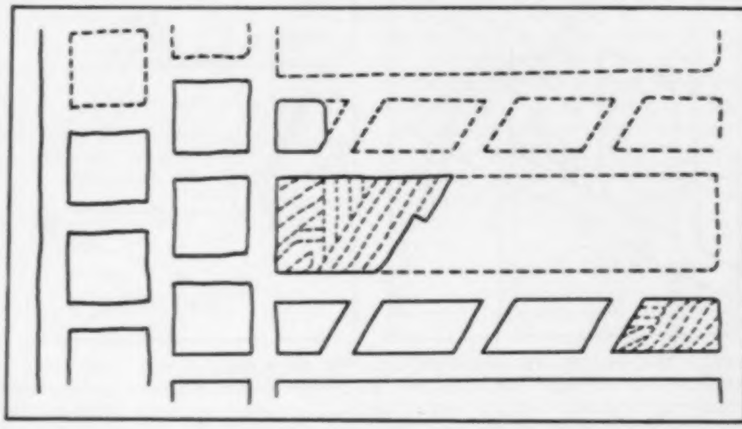


SLABBING PLAN uses extensible belts with boring-type miners to drive 600-ft rooms with one crosscut halfway up and another at end, using blowers. After miner moves, room is center cut 11 ft deep on both sides, and the coal is shot and placed on belt by crawler loader.

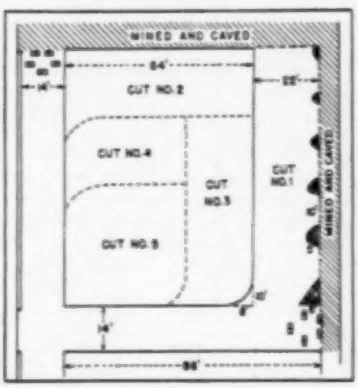
Pillaring Planbook, Continuous Mining



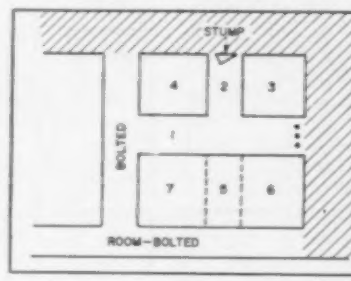
CONVENTIAL OPEN-ENDING is one of several types employed in continuous mining and is facilitated by speed of extraction, in turn easing the support problem. Simplicity is another feature, not only in mining but in ventilation and moving of equipment.

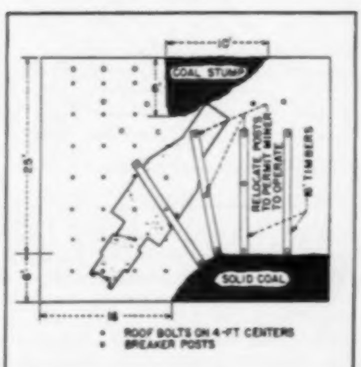


ANGLE OPEN-ENDING combined with 90-deg development. Top is medium hard and places are driven 16 ft wide on 50-ft centers with boring-type miner. Solid pillars between pairs of rooms provide much of the tonnage. Angling favors the boring-type continuous machines.

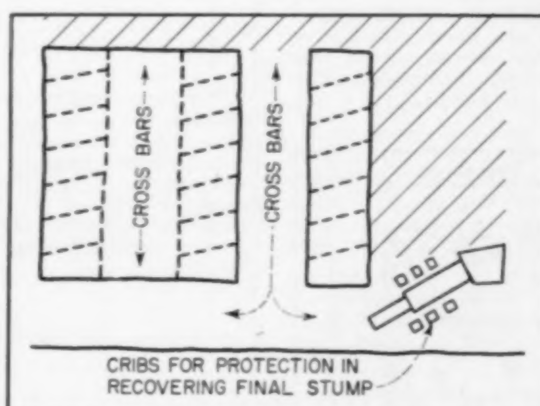


SPLITTING in its various modifications is a popular form of pillar removal. Normally it provides the maximum in coal for holding weight until final wing or stump removal. This conventional plan leaves big corner stumps plus a small triangle in the secondary split for protection.





OPEN-ENDING WITH SMALL COAL STUMPS for additional support and protection of the lift across the pillar. The stumps supplement roof bolts and crossbars placed as in the lower diagram. Ripping-type machines are employed for the mining operation in thick coal with a drawslate top.



WINGS ARE OPEN-ENDED in this splitting plan for drawslate. Semirigid miners are employed. Bars in splits are held at the gob end by bolts and, at the solid side, by posts, which remain and act as breakers when the next split is mined. Limiting posts to only one row also reduces interference. Cribs are set on each side of the miner in taking the final pillar lift.

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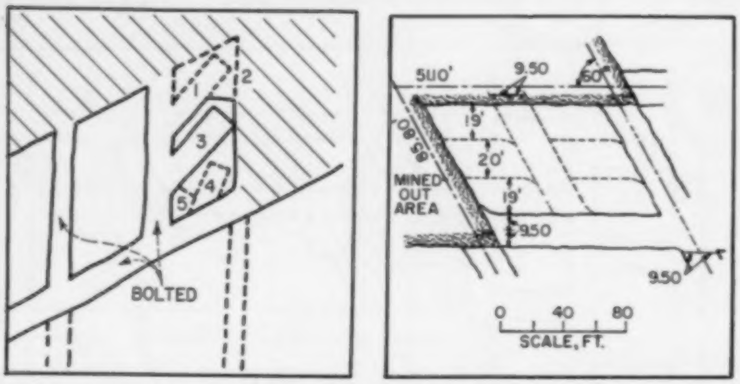
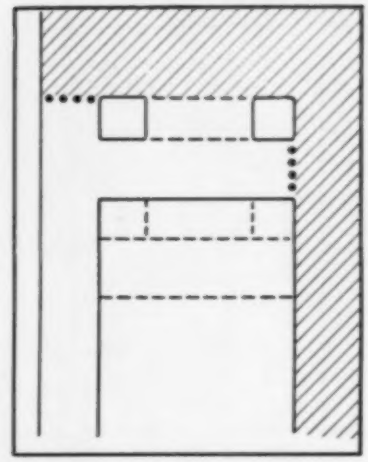
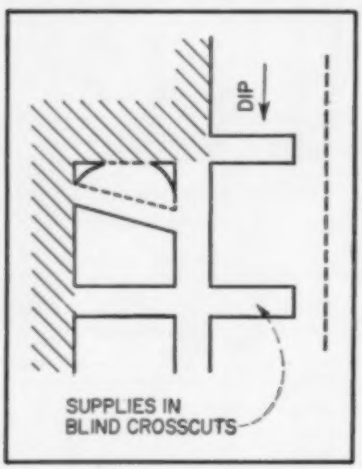


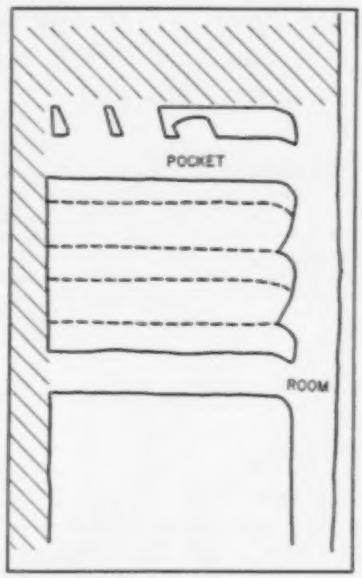
SPLITTING PLANS FOR DIAMOND-SHAPED BLOCKS. Left view shows 60x70-ft blocks, 4- to 6-ft coal, firm shale top, boring-type miners. Fast extraction permits recovering two halves with posts only. Right view, semirigid machines, shows splitting on shorter axis recovering halves open-ended. Square blocks also can be mined with similar plans.



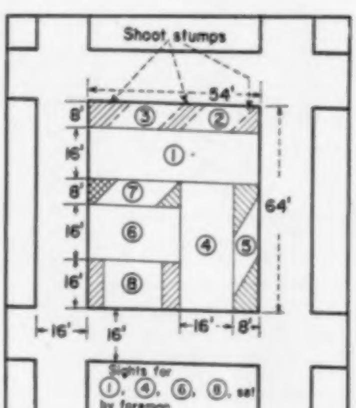
POCKET PLAN of the conventional type includes wings which are split to leave final stumps.



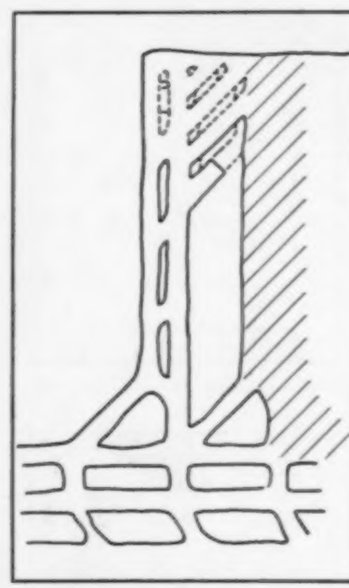
SLANT POCKET is employed in pitch-mining plan with ripper-type machines. Final extraction involves splitting wing on the upper side. Inclination is 12 to 15 deg.



WINGS in this pocket plan for ripper-type machines are formed in 85x85-ft blocks by driving places 15 ft wide to leave wings 10 ft thick. These are cut through at intervals to leave small stumps. Roof is top coal and drawslate held by bolting.



ALTERNATE LIFTS are taken from two sides of the pillar in this plan for ripper-type machines in thick coal with drawslate top, roof-bolters on the miners. The 8-ft wings are removed by cutting through at intervals and shooting the stumps.



ANGLE POCKETS with thin fenders rather than thicker wings distinguish this plan of mining. Basic development with boring-type equipment is on 90 deg. Rooms are driven in pairs and the thick pillars between pairs are removed by subsidiary pockets. The final operation is splitting the chain pillars and fenders, as shown.

The Deep-Mining Guidebook . . .

Conveyor and Machine Loading

Equipment Selection

THIN COAL—New loading machines are being designed to get down into fairly thin coal and should be used where possible. If loaders are not feasible, use self-loading conveyors, other things being equal.

THICK COAL—Use the highest-capacity loading machines and transportation units available, other things being equal.

PITCHING COAL — Use conventional conveyor or mobile equipment up to 8 to 10 deg, conveyors up to 18 to 20 deg, sheet iron up to around 30 deg and longhole drills on the steeper pitches.

WITH THE VARIETY of conventional units available today, it is only under exceptional conditions that the choice is limited and only one or two possible types can be installed. One exception—for the moment—is flat or mildly pitching seams under 30 in. Even here, there is still some choice of self-loading equipment, including the scraper and the duckbill or sawbill. Hand-loaded equipment includes the hoist-operated, scraper-type hauler and the various forms of room conveyors—chain and shaker principally.

The equipment noted in the preceding paragraph also may be used in the thicker coal, and is fairly common up to 4 ft, but the development of on- and off-track loading units, which offer the advantages of flexibility and high capacity, along with ease of moving, has resulted in their taking over to a considerable extent in coal thicker than 3 to 3½ ft. Off-track haulage equipment normally accompanies off-track mining equipment, though it is being challenged by the extensible belt, the bridge conveyor and other new conveying developments providing very close to continuous haulage. Such units also can cope with very soft bottom which, in the past, has resulted in a few instances of adoption of track haulage even when rubber-tired haulage units were available.

PITCH EQUIPMENT – Conventional conveyor and mobile equipment can be used with a high degree of efficiency up to approximately 18 to 20 deg. At 10 deg or less there is only a slight difference in results, if any. Where haulage is concerned, the breaking point where conveyors usually must be substituted for rail cars or shuttle cars usually is around 5 deg. However, rubber-tired equipment has been used in crosspitch rooms or chambers to around 12 deg. The maximum pitch on which mobile machines may be employed is yet to be determined though up to 18 to 20 deg has been achieved.

Explosives and gravity remain the major production tools where greater than sheet iron pitches are encountered. To make it possible to bring these forces into play with a minimum of labor, major emphasis is being placed on the development of the longhole drill.

Practice Trends

HAND-LOADED AND SELF-LOADING CONVEYORS being more and more limited to very-thin coal or special conditions. Retreat on both sides of a panel the most-common conveyor plan.

STANDARD LINE OF LOADING MACHINES for normal thicknesses of coal being expanded by units with capacities up to 15 tpm for very thick coal, and by thin-vein units for coal as low as 28 or 30 in. Increase in the availability of thin-vein units altering significantly the basic production picture in such veins.

BRIDGE CONVEYORS growing as a means of insuring high productivity through continuous haulage, especially in the thinner seams. Otherwise, shuttle cars get the call.

BLOCK PLANS with bleeder openings becoming more popular. "Flat" or low angle pillar lines finding greater application.

LONGHOLING continuing to gain as a means of mining heavily pitching coal.

Conveyor Mining

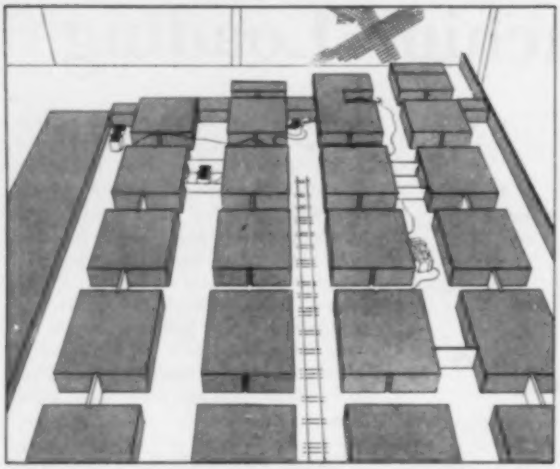
Concentrate conveyors into groups of two and preferably four or more.

Drive up first and mine rooms and pillars on the retreat. An acceptable alternative under most conditions is advance on one side while driving the entry and retreat on the other.

Schedule operations at the face so that loading is carried on with a minimum of interruptions for cutting, drilling, shooting, timbering and so on.

Select mining plans that cut moving time. Try to buy or redesign all types of conveyors to facilitate moving and save time. Use pullers or carriers—home-grown or purchased—to ease the moving job.

Conveyors today normally are used in groups of two to four, although the



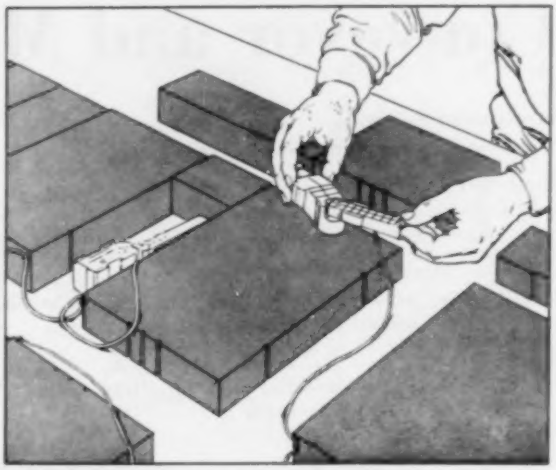


TABLE-TOP MINE MODEL provides an opportunity to solve problems quickly and easily, saving trial time and money.

variations are almost infinite. The benefits of grouping are those usual with concentration. Single conveyors are found mostly in pitching coal, and in second or third mining of anthracite. And whether single or multiple, in rooms or in entries, conveyors usually discharge either to a panel belt or to a gathering or cross conveyor concentrating the output at a single car-loading point.

Chain conveyors of the conventional type require a drive for any change in direction. However, the "snaking" or "python" conveyors used abroad are designed to permit a certain amount and sometimes considerable bending in service. As a rule they are much heavier, however, than the commonly used U. S. types. It is possible to bend standard chain units slightly, though it is not recommended because of increased wear. Thus, when hand loading onto chain units, it is necessary to keep place width down to practical shoveling distance unless face conveyors are used. With face units, rooms can be driven 50 ft, 60 ft or more in width where roof and other conditions are favorable. Wider faces ease the problem of arranging the cycle so that loading proceeds with minimum interference and maximum efficiency. And even though the face conveyor is longer, putting it on wheels or rollers and designing the joints for quick breaking and making (*Coal Age*, October, 1952, p 77, for an example) permits rapid moving even where close timbering is necessary.

SWIVEL AND TURNS—With shaker conveyors, swivels make it possible to swing the face end rather readily, provided jacks and posts do not interfere. Thus, within limits it is possible to widen the place without going to face units or turning the trough. At the same time it is possible to keep the face end of the conveyor in the most favorable position for hand loading. Ability to use swivels and turns permits driving crosscuts and working pillar places without separate drives. Bellcranks also permit operating separate trough lines from the main unit as desired. Uphill types with curved discharge chutes also can lift coal or rock and load it into cars without auxiliaries.

Adding a duckbill or sawbill makes the shaker conveyor self-loading. Power swing and power advance and retract also are available on duckbills. Compared to loading by hand, adding a duckbill, sawbill or power duckbill increases the number of cuts that can be mined in a shift by from one to three, thus, in some instances, as much as doubling the output per shift.

Cutting Moving Time

One of the biggest headaches in the use of conveyors of the conventional type is not only extension time but also moving time. Though there are not too many, some methods for saving in moving time do exist. As previously noted, equipping face conveyors with rollers is one. Couplings that are quick to lock and unlock, and special tools for break-

Operating Reports

Loading in 26-in Seam—Thin-seam loaders coupled with bridge conveyors and 13½-in high rope belts promote efficiency. Specially designed low-slung compressors and supply cars are key units. Full retreat mining the rule in panels with pairs of rooms driven both ways. *Coal Age*, April, 1957, p 60.

Loading in 5-ft Seam—12-man crews with crawler loaders load to shuttle cars tramming to panel belts. Both AC and DC employed. *Coal Age*, June, 1957, p 74.

Concentrated Mining in 7½-Ft Coal—Big loaders and auxiliaries work in 7-place sections. Crews of 13 men, including two bolters (fair to poor top) average 600 tons per shift. Each loader is served by two shuttle cars delivering to belts. *Coal Age*, October, 1957, p 76.

Contour Mining After Stripping—Crawler loaders served by shuttle cars and belts mine 40 to 56-in coal. General dip is 8 to 12%. Irregular area requires frequent openings around outcrop, each provided with bin for transfer to trucks. "Middleton wheel" solves problem of centering coal on belts. *Coal Age*, December, 1957, p 54.

High Tonnage in 36- to 48-in Coal—New high-capacity low-vein loaders served by shuttle cars and rope belts handle bulk of output at two new mines developed with 8-heading mains and 5-heading panel entries. Panels are worked against the air—advancing on the return side and retreating on the intake.

ing and joining chains are among them.

The time-consuming and costly job of moving from one place to another can be materially eased by at least certain steps, including the following:

1. Turning the moving job over to special crews.

2. Using pullers and carriers to eliminate most of the physical effort and much of the time involved in shifts from one place to another. Shortwell trucks of the crawler or rubber-tired types can be used for carrying or towing or both. Or pullers and carriers specially designed for the job, including the necessary winches, may be purchased or made.

3. Using mobile drive sections. These mobile sections, mounted on crawlers, have made it possible to move an entire room unit completely in as little as 1½ hr.

MODIFIED MINING PLANS—Certain mining systems help in cutting down on charges for moving conveyor parts and such materials as crossbars and the like. If only one place is worked at a time, as an example, blind cross cuts may be driven toward the next place, and pans, chain and materials may be stored in them for pickup as the new place comes up to the crosscuts. Or, the conveyor line may be left intact in the old place to permit pans to be taken off as needed and moved through the crosscuts.

Special mining plans designed to reduce moving time include the "continuous-room" setup shown in the Planbook later in this feature. One place, it will be noted, serves as a beltway with a cross unit bringing the coal over from the others. When the "rooms" have advanced the set distance, another cross unit is installed after the drives for the room conveyors have been moved up. Moves thus are made straight ahead and over a minimum of distance, reducing the time requirements.

"Panning up," or conveyor extension, when done section by section, interrupts face operations and requires both time and labor. The bridge conveyor is one method of reducing the number of interruptions and the time required. In fact, the first bridge unit was developed to reproduce pan-up time in hand loading, but was quickly adapted to carrying coal away from loaders and continuous miners because of its manifest advantages.

Conveyor Plans

The plans adopted for conveyor mining are as numerous as the variations in equipment units, but the most-used ones are two:

1. Driving the room entry up the full distance and then working rooms on one or both sides on the retreat. If the mining is done on both sides of the panel, one equipment unit may alternate, or matching units may be used on both sides (see auger-head mining plan in the Continuous Mining Planbook). The conveyor layout is typical of those used with hand or machine loading.

Where the coal pitches and entries or gangways are driven on the strike, places are turned up the pitch.

Occasionally, as demonstrated in one of the systems in the Mechanical Mining Planbook later in this feature, a subopening may be established up the pitch to permit two or more groups to be operated in cascade fashion. A variation is driving stubs up the pitch, equipping them with proper lowering equipment, then turning rooms across the pitch starting at the top of the stub and working down.

2. Developing the room entry and at the same time working rooms on one side of the advance, then completing the panel by retreat on the opposite side, is another common conveyor system. This normally results in a more even output rate over the life of the section, and also keeps all working sections on the fresh-air side of the panel ventilating system. In driving and advancing on one side, the entry, as shown in the accompanying plan (see Planbook), may be advanced a certain distance and then the equipment moved into the rooms to mine them out, after which another entry advance is made.

In any system, most operators like to prepare room necks in advance. Thus, if the entry is completely developed in advance, places may be necked 2 to 3 cuts on one or both sides to be ready for final mining—that is, with a two-heading entry. However, if chain-pillar crosscuts are made on room centers necking may be unnecessary on one side. And with a three-heading entry, with the belt in the center, crosscutting on room centers can eliminate any necking on either side, though many operators still feel that it is worth driving in to the point where room widening starts. Also crosscutting on such short centers may be undesirable from several standpoints, including extra stopings and more likelihood of roof trouble.

PILLAR EXTRACTION—Where the coal is under 3 or 3½ ft and the top permits, many operators prefer to reduce pillars to a minimum and leave them, some arguing that the value of the coal left is less than the cost of the timber that would have to be put in to recover it. In at least one instance part of the pillar is pocketed out and the remainder left to protect the next pocket, eventually crushing with subsidence of the top. Where pillars are taken, usual practice is to widen to one side only, putting the conveyor along the straight rib where it is close to the pillars to be removed.

Unit Organization

In addition to the room and—possibly—face and cross conveyors and elevators, the usual practice in setting up a conveyor unit is to put a shortwall cutter and a drill in each place. Attempts to move cutters from place to place make it difficult to set up a tight face cycle, which is essential for maximum efficiency. Drills may be separate, each with its own cable, though a common practice is to plug drills into cutting machine takeoffs.

Flexible-shaft drills, likewise operating from cutter takeoffs, have made major strides in conveyor and other mining in recent years, as has the hydraulic hand-held drill powered either from the hydraulic system on the cutter or, if the cutter has no hydraulic facilities, from a special hydraulic portable pump.

Other equipment frequently found in a conveyor setup includes specially designed rockdusters and bolting units.

SUPPLYING CONVEYOR UNIT — Supply-handling equipment includes wheeled dollies operating in pan lines, and small hand or powered winches to pull timber and other heavy materials up to the face.

The false pan line is a simple and effective alternative in flat or mildly pitching coal. Until the halfway point of the place is reached, a false line is built alongside the regular line by pulling it forward and attaching a section each time the regular conveyor is extended. Each new false pan is loaded with enough supplies to take care of that much advance of the face, and the line is pulled up by the cutter so that the inby pan can be unloaded and added to the regular line. When the last section of the false line is pulled up, the room is completed.

Outby the rooms, supplies may be brought in by rail trucks, by rubber-tired equipment or by reversing the panel belt. Some belts have been fitted with jogging and inching controls for this purpose (*Coal Age*, April 1946, p 86).

Scheduling Face Work

The usual face crew, whether loading by hand or power, is 3 or 4 men, with as high as 10 to 12 on extra long faces. Average output, in hand loading, is 1 to 3 cuts in the usual rooms. With self-loading equipment, production is increased to 2 to 4 cuts per shift—sometimes more.

Attaining production rates of this magnitude requires a careful study of crew size and operating cycle. Unless places are extra-wide or some special situation

exists, the usual face crew, as noted, is 3 to 4 men. More than that number under normal conditions seems to result in interference and lost time.

The cycle itself is the critical factor in high productivity. For high efficiency, the various elements in the cycle—cutting, drilling, shooting, etc.—must overlap, and must be tightly scheduled to prevent waste motion and time loss. The basic goal is as little interruption in the flow of coal as possible. The best way of attaining it is through time study and the establishment of a fairly rigid system of standard times, plus a fairly exact schedule of when to do what.

Machine Mining

Take pillars to increase recovery and cut development cost. Consider the advantages of the flat pillar line.

Provide enough places so that coal is always available.

Keep haulage distances short. Consider the possibilities of bridge and extensible conveyors.

The basic machine-mining unit, meaning here the unit based on a mobile loading machine, is made up of the loader itself, a cutter, a drill and, in most instances, one or two shuttle cars. Additional equipment may include a roof-bolting unit, a rock-dusting machine and a mobile supply truck.

A high degree of flexibility characterizes this unit, and thus it has been applied in practically all types of mining, including semilongwall, in both thick and thin coal and in both flat and lightly pitching seams. Number of working places per unit ranges from a low of two up to 20 or more. The average is 6 to 10. Crews range from 3 to 5 up to 20 to 25 men, with the most common around 8 to 12. Production per unit runs from as low as 100 tons up to as high as 1,500 tons per shift, with 300 to 600 tons as the majority. Tons per faceman ranges from 20 to nearly 100 in a few instances, with 30 to 50 perhaps the most common.

Machine Projections

Because of the flexibility of the load-unit previously noted, mining plans range from completely closed panels with no pillar extraction to what might be termed the wide-open system with all openings—entries, rooms and crosscuts —projected on the same centers. This latter, if followed completely, results in dividing the coal into blocks of uniform size, permitting both flexibility in attack and, at the same time, a standardization of extraction methods conducive to both high unit productivity and high tons per man.

LOW-ANGLE PILLAR LINES – Where pillars are removed with machine units, the tendency is to reduce the angle of the pillar line from 45 deg sometimes down to zero or to a completely flat line. Two major advantages result. One is that the span supported on the projecting points or stumps is materially reduced in going from 45 to some smaller angle. On a flat line the span vanishes. And as the span is reduced, the weight of top in the angle requiring support is reduced accordingly. In one instance a change from 45 to 22½ deg, with a minor change in block centers, cut the weight to be supported to one-third of the total under the 45-deg plan previously employed.

Whether short lines or stepped lines are feasible is another question in projection. Each case must be studied individually but there are instances of successful operation with very short lines. Also, there are instances of steps of considerable magnitude in lines as a result of permitting entry recovery to lag behind to provide room for a tail track, as well as permitting one group of rooms operated by one mining unit to get considerably ahead of the next group. The conclusion therefore is that with most top there is considerable flexibility in establishing and operating pillar lines, though, other things being equal, a reasonably long straight line normally provides the maximum results with a minimum of trouble. And whatever the system, a cardinal rule is getting the coal out clean or making sure that any pillars or stumps that cannot be recovered are shot before they are left.

PLANNING WITH MODELS—To reach better answers to questions as what methods are best, at least one operating company uses table-top models. The elements in table-top modeling are blocks of the correct size to represent pillars; cardboard or other sheets to represent stoppings and brattice lines; wire or cord for cables, etc., plus miniatures to scale of the machines. When a problem, such as where to anchor shuttle-car cables, comes up, it can be solved by setting up a typical working section and experimenting to find the best spot. Cuts of coal can be added or subtracted by using small blocks and an entire pillar-recovery cycle can be run through as examples of other things that can be done.

The overall look afforded by the table-top model makes it easier to see all the elements of a problem and thus frequently points to the obvious solution immediately, saving time spent underground and on experiments that do not work out (*Coal Age*, August, 1957, p 74).

PREVENTING BUMPS—In brief and perhaps oversimplified terms, bumps are the result of a concentration of stress in the interior of a block or blocks of coal as a result of weight. As the weight builds up, the coal in the pillar is stressed more and more, until it suddenly fails in explosive or semiexplosive fashion.

Preventing weight buildup is a combination of a number of things as outlined in a more detailed discussion of bump prevention in the section on "Roof Control." Careful study will permit evolving a mining plan which will eliminate or reduce load buildup of the type which results in bumps.

In addition to mine layout, pillar design and pillaring system, bumps may be avoided by drilling or augering suspected pillars. In this process, the weight is unloaded gradually, or the bump is triggered while the weight concentration is small and before actual mining of the pillar starts. For a fuller description of the pioneer drilling and augering plan for bump control, see *Coal Age*, January, 1955, p 68.

Machine Plans

A key factor in efficient machine loading is coal and transportation at all times. An adequate coal supply requires, among other things, an adequate number of places in which to work. The basic rule is that as soon as the machine is finished in one place coal should be ready in the next for loading. Acceptance of this rule means that with conventional room haulage—usually the shuttle car—the minimum number of places usually is four, exclusive of crosscuts. In the past, however, some operators have approached the question from the standpoint of high tons per man from a small crew in two to three places. If tons per man are high enough, they compensate for the fact that fewer tons are secured per dollar of investment in machines. New equipment, on the other hand, removes this objection to a small number of working places. The bridge conveyor is an example, but even with it there should be enough places so that the loader never has to wait for coal.

SHUTTLE-CAR HAULAGE—Though there are many variations, the section layouts for shuttle-car haulage tend to be one or the other of two types:

1. **The panel plan with rooms turned both ways and driven in groups of 5 to 7 or more.** One reason for the use of this plan is the fact that pillars are not recovered. However, with modifications, pillaring can be done with this plan also.

2. **The conventional block or room-and-pillar plan devised for pillar mining, either with short lines for each room**

section or longer lines advancing continously from section to section. To faciltate the latter, some block plans, as noted in the Planbook elsewhere in this section, are set up with all openings on the same centers so that pillar lines can be established and advanced without having to shift gears when an entry is crossed.

In developing for both plans, the usual practice is to drive a minimum of 4 or 5 headings to make entry work as near like room work as feasible and thus as efficient as possible. Heading stations are established every 200 to 300 ft, at which distances the shuttle-car haul is kept under the generally accepted maximum of 500 to 550 ft. If track is used, it may be looped completely, or may be turned into a room or back down the next heading to establish a tail track for transfer from shuttle car to rail car.

ANGLE CROSSCUTTING—Crosscuts may be angled each way from the center heading to facilitate higher-speed shuttle-car operation. This is especially true in operations based on mining individual panels, and particularly where pillars are left. In some plans, the angle crosscuts continue to become rooms, with angling continued in making room crosscuts. In a group of five or more rooms for example, the center usually becomes the key room, often leading directly to the car or belt-loading station. An example is shown in the Planbook later in this feature, 34-in coal, center heading brushed for track haulage. The rooms are driven in groups of 5 or 7, depending upon conditions and equipment. A second plan for thick coal shows double-tracking of the panel entry for faster trip handling. Mining in this instance is done on the advance.

Three other plans show right-angle development for pillaring. Depending upon the particular setups, they also show loop track and bleeder openings, the latter in one instance being formed by leaving the pillars on one side of the panel entry.

With track setups, all shuttle cars normally must dump at the same point. Consequently one must occasionally wait on the other. Where panel belts are used instead of track, however, some operators restrict one shuttle car to dumping at the end and require the other to use a crosscut farther down to prevent interference and loss of time in waiting to use the same dumping point.

TOP BENCHING – Extra-thick coal offers some special problems in machine mining. At one mine, as an example, though the mining system went through a number of changes, all openings invariably were driven along the bottom. Top and rib deterioration and the onset of weight always outpaced the rate of extraction, thereby making it difficult to achieve the desired recovery. The cure was found in driving the openings in the top of the seam and bolting the roof, which permitted fast, economical removal of the lower portion of the pillars by loader or scraper (*Coal Age*, November, 1954, p 92).

TRACK HAULAGE – In loading directly into mine cars, maximum efficiency involves these steps:

1. As big a mine car as possible to reduce the number of changes per cut.

2. A one-way distance back to the closest changing point of not over 150 ft.

Prefabricated track provides a reliable means of attaining the second objective, as well as the further goal of track that can be installed, taken up and moved quickly and with a minimum of labor. Prefabricated track also forces adherence to the mining plan, which is helpful over both the short and long pulls.

CONVEYOR HAULAGE—Being a continuously operating haulage unit, the conveyor was early seized upon for service behind loading machines. The difficulty of keeping the machine discharge over the conveyor, with consequent loss of time by the operator, added to the time and cost of moving the conveyors, resulted in, first, a trend to mine cars and, next, to shuttle cars. New types of units, however, are putting the conveyor back into the loading-machine picture. One example is the bridge conveyor, which is connected directly to the loader, plus mother or cross conveyor, line. Another is the extensible belt.

Bridge-conveyor plans normally are based on two or three places per unit. Basic equipment in the unit is two or three room conveyors, two or three bridge coveyors, a cutter and drill in each place, and a crawler-mounted loader, plus mother or cross conveyor, elevator, car-spotting hoist, roof-bolter, rock-duster and so on. The loader moves from place to place, and a mounted cutter may be subsituted for the individual shortwalls, alternating with the loader. In general a good top or one which lends itself to bolting facilitates the use of bridge conveyors by making it easy to establish the necessary travelways.

Operation is much the same whether rooms or entries are being driven. An entry driving setup is shown in the "Opening and Development" section of this issue. Average performance in 34-in coal is 20 to 25 tons per faceman. One element in this performance is a tight well-balanced cycle, involving four men approximately 30 min in preparation and two men 30 min in loading, as follows: (1) two men drill two shot holes; (2) two men sump cutter; (3) one man continues to cut while helper and third man drill three remaining shot holes; (4) one of the latter two loads, tamps and prepares to shoot while the other sets permanent timbers to replace safety jacks; (5) fourth man installs conveyor pan and cleans up loose coal; (6) face is shot; (7) loader crew of two men loads out the cut. Note that preparation and loading require identical times, meaning no lost time for the loading machine.

A panel setup for bridge conveyors is shown in the Planbook in this section. Coal thickness is 26 to 36 in. The mining plan (*Coal Age*, April, 1957, p 60) is full retreat with pairs of rooms turned right and left off the panel entry. Panel haulage is by belt. Average output is 21 to 22 tons per faceman. A pair of rooms is completed in about five days. The conveyor lines are left in place and the mobile drive sections are trammed to the new sites with enough pans and the tail section to start the new rooms. Equipment moves take about 5 hr and are made on the third shift by six men from the regular crew.

Pillaring Plans

Loading machines can be used in practically any system of mining individual room pillars, including slabbing and splitting. The two most-used plans, however, are open-ending and pocket-and-stump. Examples of these and other plans are shown in the "Continuous Mining" section of this Deep Mining Guidebook.

A variation of open-ending is pocket-and-fender, under which the stump is cut down to a shell only 2 to 3 ft thick. A subvariation is gripping the cutting machine out each time to make a saw-toothed fender and increase recovery slightly. Timbering plans for pillar mining are discussed in the "Roof Support" section.

In open-ending, it usually is best to arrange the direction of advance so that the machine operator is on the side away from the coal and protected from sloughing and rib bursts, particularly when heavy weight is the rule and the coal is soft.

Pitch Mining

Use self-loading conveyors or scrapers, standard loading machines or continuous miners on light pitches. The latter normally provides highest tons per man where conditions permit use.

Use longhole methods in heavy pitch; as an alternative, use a slant-

chute system. Consider the possibilities of induced caving. Bore crosscuts to save labor and cut stoppings cost.

Pitch mining may be defined as mining on grades greater than those that can be negotiated readily by mine cars or shuttle cars, or around 5 to 6 deg. The maximum on which crawler-mounted equipment can be moved without too much difficulty is around 15 deg. Light-pitch mining may therefore be defined as mining between 5 and 15 deg. Heavy-pitch may be defined as the degree of pitch at which the coal will run on the bottom. This normally is something over 35 to 40 deg.

Light Pitch

Practically any type of equipment may be used at the face of places driven either up or down light pitches. Normally, however, some form of conveyor is necessary for transportation. With this limitation, all the ordinary panel plans, with or without pillaring, and practically all the conventional face equipment may, as noted, be employed. Usually, particularly as the pitch increases, the practice is to put headings up, down or both—usually up—and rooms across the pitch. Among other things, this permits the use of shuttle cars on pitches up to 10 to 12 deg or perhaps slightly more, the cars discharging to either a lowering or hoisting conveyor relaying the coal to the main-haulage system. Angle crosscuts between places permit easier movement of units from place to place in conventional machine loading.

Moderate Pitch

Galvanized iron kept wet provides perhaps the flattest gradient on which coal will flow of its own accord. The minimum is around 20 deg. At about 25 deg, coal will begin to flow on ordinary iron and, at something around 35 deg, on wood. Below approximately 20 to 22 deg, therefore, it normally is necessary to install conveyors to move coal down the pitch.

Where pitches of this degree prevail, customary practice is to sink belt or rope slopes, turn gangways right or left on a grade rising slightly to facilitate water flow, and then work rooms up the pitch, using hand labor to get the coal to the conveyor or chute. Modifications, however, include a few plans for crosspitch room work. One involves driving a pair of rooms up a 40-deg pitch and installing in one a timber track with hoist, a ladder and a chute. Rooms are turned 90 deg across the pitch, and a shaker is installed along the lower rib of each one, with a second pan line along the upper rib which serves to bring in supplies.

Heavy Pitch

Attempts to eliminate the high percentage of hand labor necessary in steeply pitching seams have been only partly successful, though the introduction of longhole drilling is beginning to alter the picture substantially. It too, however, requires a fair amount of hand labor in driving openings for air and for preparing the sites and faces for longholing, though not as much as previous systems.

Initial longhole experiments go back over 20 yr in the anthracite region, with a lapse of over a decade after the first trials. Meanwhile, to alleviate the labor and difficulty of advancing breasts straight up heavy pitches, attention was concentrated on plans which would cut down the pitch of openings in which men had to work to that on which coal would run on either iron or the natural rock, meaning to a minimum of 35 to 45 deg. The "lattice," "diamond," "slant-chute" and other similar plans were evolved, differing largely in details—for example, 30-deg openings with sheet iron and without batteries in one "diamond" plan, compared to 45-deg openings, no sheet iron and batteries at intervals in one "slant-chute" system. In both, the openings are first developed to the old gangway above and the pillars are recovered on the retreat back down. Usually, one-third to half of the pillar is drilled with holes up to 45 to 50 ft, loaded with explosive laced with detonating fuse to insure complete detonation, and shot. The coal then flows to cars in the gangway, controlled as necessary by checks or batteries. In the slant-chute system a new battery normally is built immediately below each time a new section of pillar is shot.

Because life usually is long and disturbance in the vein can be substantial after mining gets well started, the trend is toward gangways in the rock under the vein, with rock chutes up to the coal. This leaves a strip of coal between the rock gangway level and the top of the rock holes. This strip may be recovered from the next gangway below, or short, level rock-holes can be driven to the vein, which then is opened up by chutes as necessary and then drilled and shot into short conveyors leading back to the rock gangway.

INDUCED CAVING — Another proposal for reducing labor in mining heavily pitching veins is "induced caving." Similar in principle to "block caving" in metal mining, the system has shown promise in its initial trial. The original idea, as developed by the Bureau of Mines, is shown in the accompanying illustration. It involves a gangway in the rock under the vein, rock holes up to the coal, slant chutes between rock holes in the vein, and undercutting of a section of the vein by drilling and shooting to induce caving.

Longholing

Variations in longholing methods largely reflect how much preliminary development work is done. As an example, in moderate pitches, the conventional chambers and crosscuts may still be driven, the principal change being an increase in the size of the pillar left. The pillars then are drilled and shot instead of being mined in the ordinary way. Holes therefore are seldom more than 50 ft long. An example of plans where the emphasis is more on drilling of pillars formed along conventional lines is shown in the accompanying illustration along with an example of longholing with a minimum of development.

Longholing with minimum development at one operation, as an example, is based on gangways and airways in the rock beneath the vein, with rockholes to the vein at intervals fitted with batteries to control coal drawoff. Holes drilled back from the next rockhole and cased with pipe insure positive ventilation behind the battery both before and after shooting. Holes also are drilled to the next level above to drain off any water that may have accumulated.

Longhole drilling is done from a heading in the coal. To start a section, two places are driven up to the old workings and the chain pillars are removed to provide expansion room for the coal to be shot. Then the coal between two rock holes is shot by three groups of three holes each, one parallel to the bottom, one angling up through the vein and one directly toward the top rock. Firing is on off-shifts or idle days.

Longholing with a little more development in the form of sub-breasts at intervals and counters for drilling the upper block is shown in another illustration. For starting, on breast is developed up to the upper gangway. After the upper block is drilled the lower is removed in similar fashion.

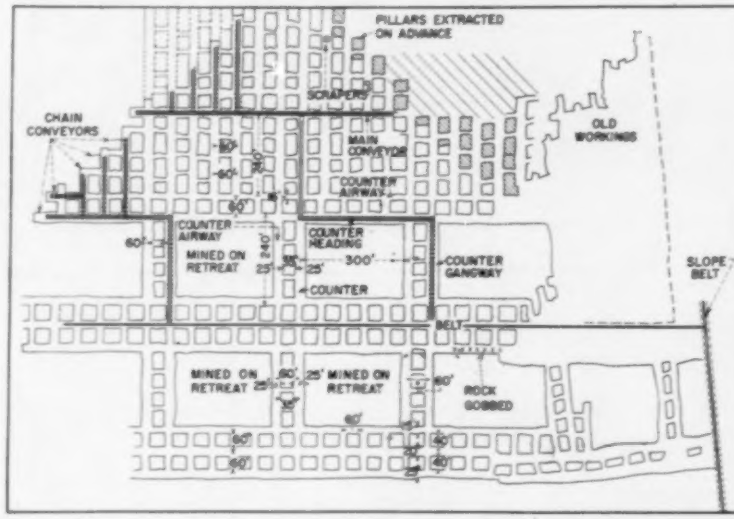
The capital investment required for longhole drilling is relatively small and productivity at the face is increased 50% or more.

Boring Crosscuts

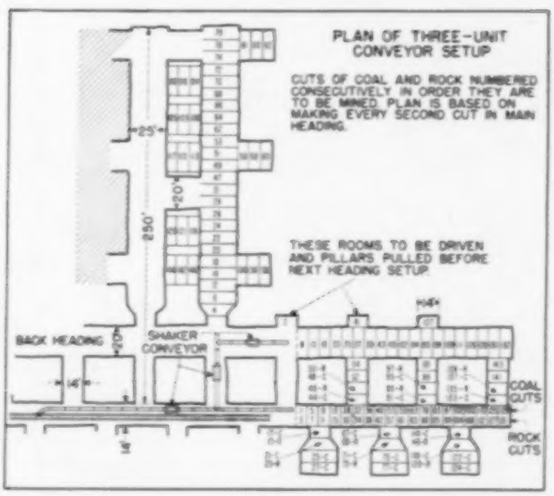
One of the more aggravating and expensive items in gangway development in coal in moderate to heavy pitch mining is crosscutting between gangway and airway. The big drill is one answer. Size may range from 24 to 42 in, and one, two or three holes may be drilled up the pitch to get the required crosscut area. In contrast to an earlier version (*Coal Age*, May, 1951, p 100) a new and much-lighter type (*Coal Age*, August, 1955, p 58) employs a hoist and rope to pull the big bit through a pilot hole. Another advantage of the bored crosscut is that a simple disk rather than an expensive custom-made stopping can be used to close it.

Mechanical-Mining Planbook

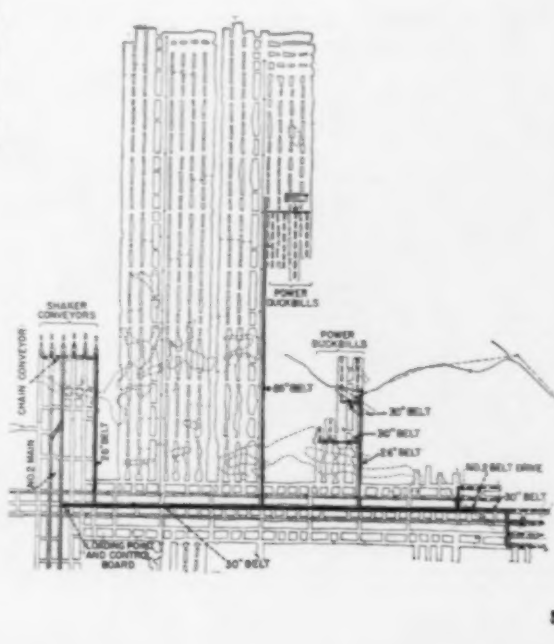
Conveyor Mining



CASCADE DEVELOPMENT up the pitch with two groups of conveyors plus scrapers for recovering pillars. Chutes and lowering conveyors bring the coal down to the main belt in the crosspitch gangway.

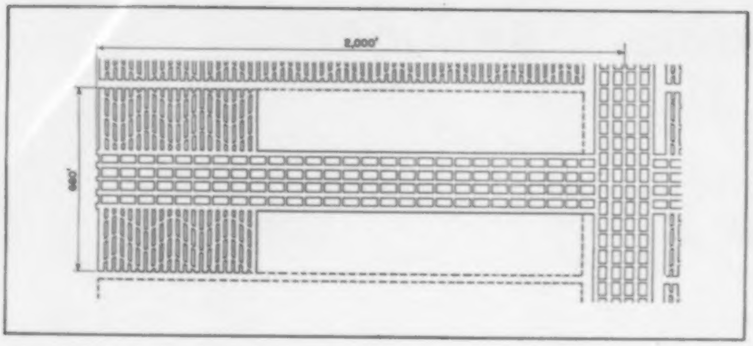


HEADING ADVANCE alternates with room work in this conveyor plan based on mining on one side on the advance and on the retreat. Rock is loaded every second cut in haulage headings, where necks are made extra deep.

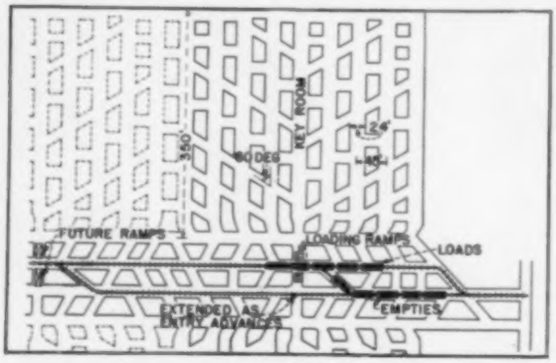


"CONTINUOUS-ROOM" PLAN for conveyor mining permits moving room units straight ahead a minimum distance by using mother and cross belts.

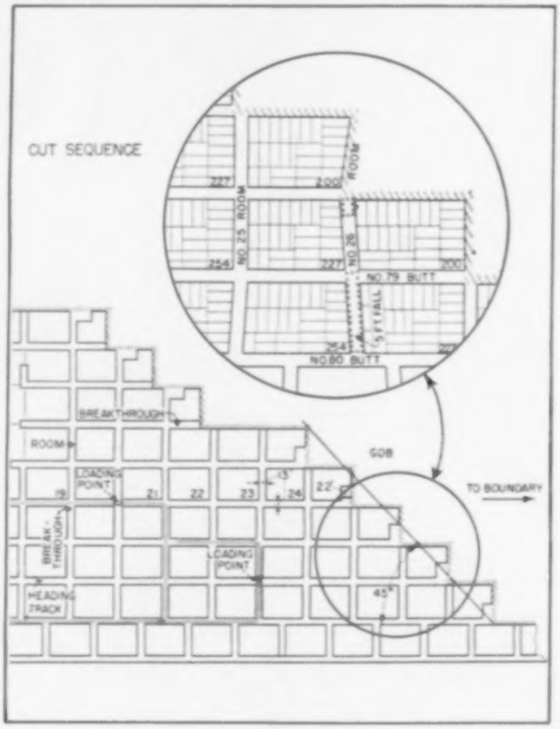
Machine Mining



KEY-ROOM PLAN with shuttle-car haulage in thin coal. The center heading of the panel entry is brushed for track and mine cars. Rooms are worked in groups of five to seven, and the crosscuts are angled from the key room for easy shuttle-car travel.

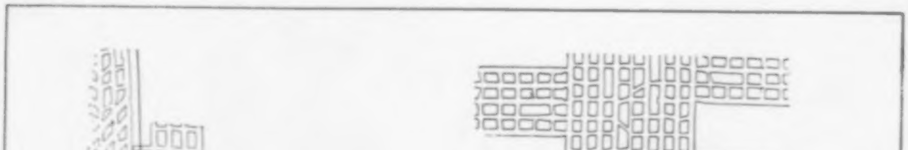


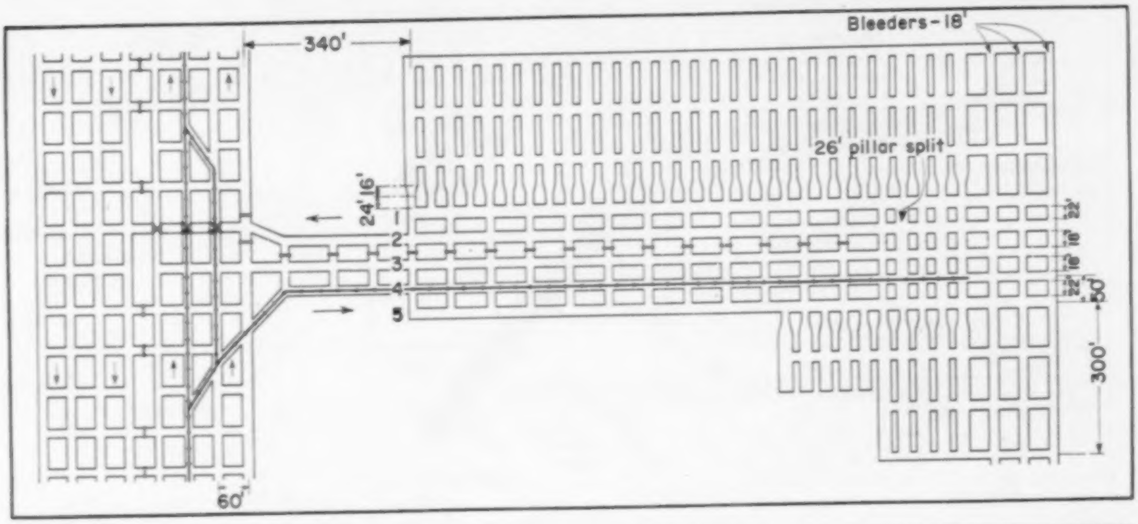
SHUTTLE-CAR PLAN showing double-tracking for mine-car loading, key rooms to loading ramps and angle crosscuts for faster shuttle-car travel.



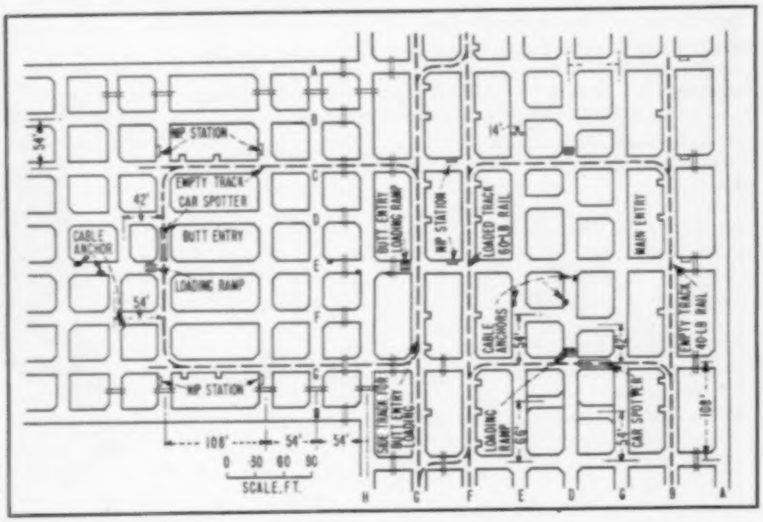
LOOP CIRCUITS simplify rail haulage and keep cars right-end-to in this block plan for shuttle cars. Pillars are open-ended in numbered sequence to provide close control of breakline. New places are developed only as necessary.

BLEEDER OPENINGS in this retreat plan are formed by leaving pillars along one side of the panel entry.



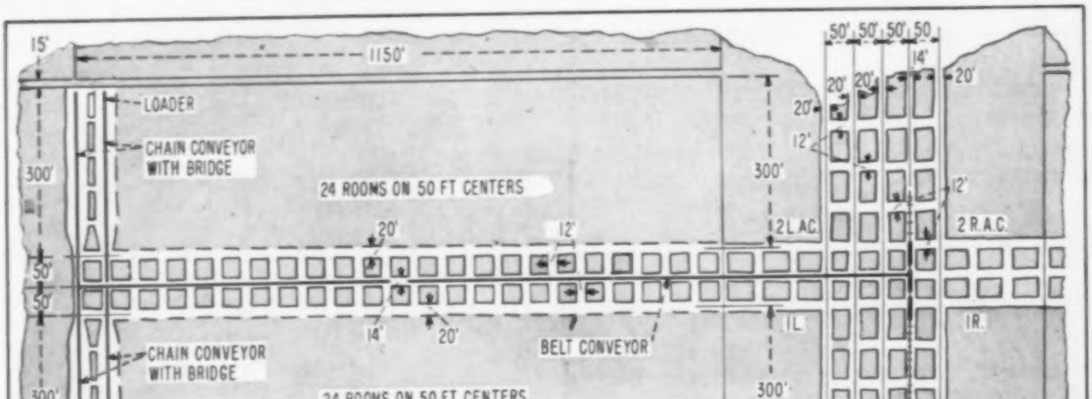


COMBINATION ADVANCE AND RETREAT PLAN keeps all work on fresh air. Places are normally driven in groups of five and pillars are left. Enlarged pillars at the top of the panel protect bleeder openings.

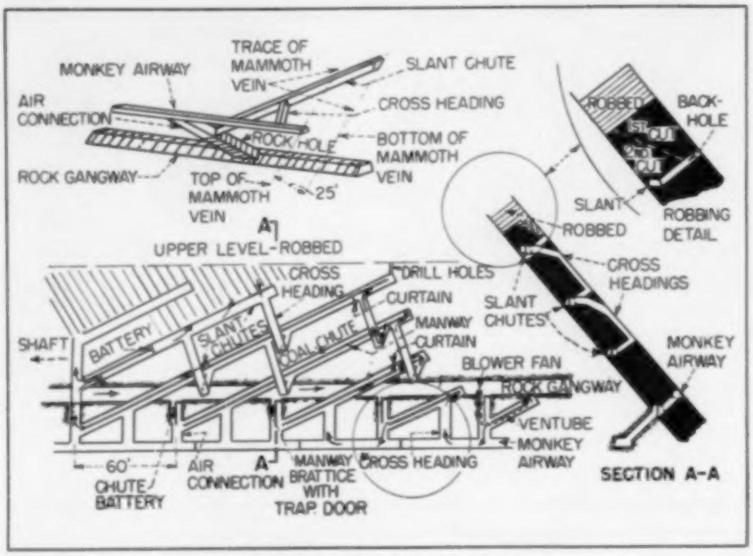


ROOM WORK is eliminated in this plan to permit straightaway advance with eight headings and mining of entry pillars.

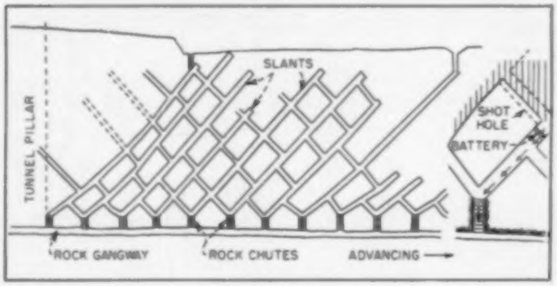
THIN-COAL PLAN is based on using bridge conveyors behind loaders in pairs of places on each side of panel entry.

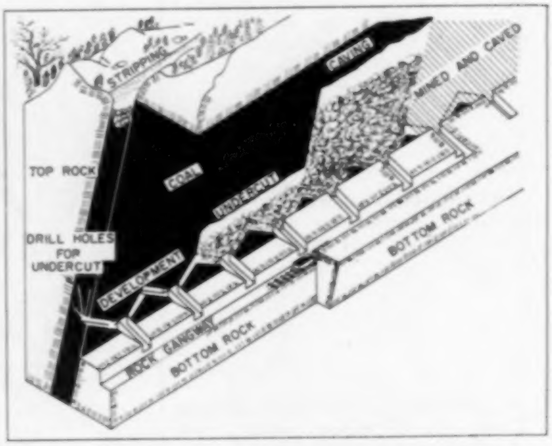


Pitch Mining

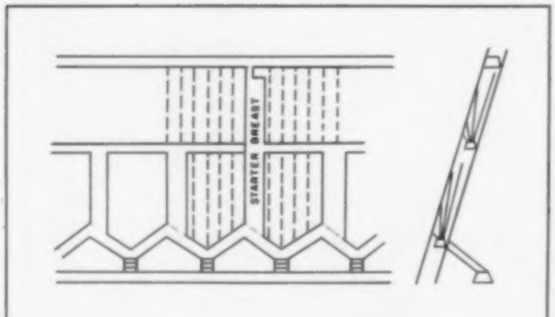


SLANT-CHUTE SYSTEMS (above and below) are examples of plans devised to reduce manual labor and raise efficiency in steep-pitch mining. In line with general practice today, gangways are driven in rock under coal.

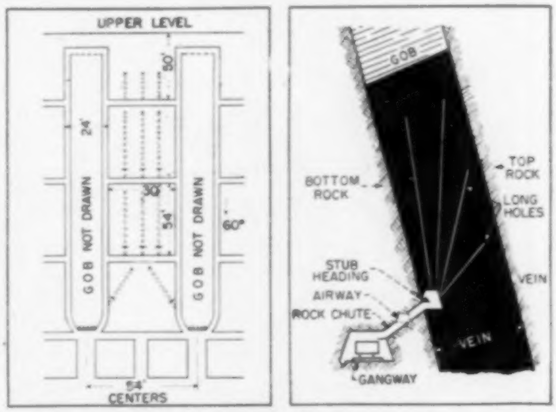




ORIGINAL INDUCED-CAVING CONCEPT for mining steep anthracite veins involving undercutting after development to start the caving.



LONGHOLE DEVELOPMENT PLANS include this version employing sub-breasts at intervals plus counters for removal of the coal in two lifts.



TWO LONGHOLE PLANS show (left) development along usual lines except that pillar size is increased to permit drilling and shooting, and (right) operating in nearly vertical vein with only drill headings in the coal.

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Face Preparation

GETTING THE COAL out of the solid in the best-possible condition for fast, efficient loading is one of the major goals in face preparation. A second major goal, where the domestic market is a factor, is getting the coal out with a maximum of coarse sizes and a minimum of fines. Thirdly, the face-preparation operation should be conducted with a minimum of expense for equipment, labor and breaking medium. The basic approach is careful, constant study of cutting, drilling and shooting, including equipment, bits, placement of cut or cuts, placement of holes, and choice of breaking medium.

Bits

Use types that cut the most in tons per dollar of cost.

Keep bits sharp for faster cutting, lower power consumption, less wear and tear on the machine, and a better size realization.

Adopt measures to prevent breakage and loss of bits.

Both their own cost and their salient effect on productivity, plus, even, their effect on the size consist of the coal, make bits important. Under some conditions, the old carbon bit, forged and quenched, can give a good account of itself. However, these situations are growing fewer, and the need for greater capacity with fewer interruptions for replacement and sharpening has resulted in the development of throwaway, hard-faced and carbide-tipped bits for both cutting and drilling. They sometimes run for days before changing and resharpening are necessary. Some designs can double in brass—for example, drilling first coal and then drawslate where it is taken down for height or for safety; or cutting in either coal or partings if required.

Aside from the desirability of keeping all possible metal out of the coal, insert-type bits cost considerable money in themselves. The rule, therefore, should be an old bit or a thorough accounting before a new bit is issued. Establishment of fixed quantities in the hands of each cutting, drilling or continuous-miner crew—or at least in each section—supplemented by regular inventories will help keep down losses. Grinding to restore bits to service condition also can materially affect cutting qualities and the total number of regrinds, meaning service life. Manufacturer's recommendations should be the guide. For a step-by-step illustrated description of grinding and reconditioning both cutter and drill bits see *Coal Age*, July, 1957, p 71.

Cutting

Use long bars, other things being equal, to reduce number of loader moves.

Consider universal machines for greater flexibility in cut positioning and because they make it possible to shear when desirable.

Both the shortwall and the rubber-mounted universal machine are the predominant cutter types today, with the latter accounting for more and more of the total tonnage because of flexibility, greater mobility and higher capacity. The shortwall, however, still dominates in conveyor mining, particularly in thin coal, and also is a part of mechanical units in thick coal at a number of mines. Hydraulic tilting makes it easier to use and adds appreciably to capacity where the cycle is tight. Bugdusters can materially reduce labor and normally make it unnecessary to clean the kerf. Otherwise, kerfs should be cleared of cuttings to promote safety in shooting, reduce powder consumption, prevent "hung" cuts and generally improve loadability. However, certain newly-developed cutting systems, notably the "three-pass" summarized later in this section, reduce or eliminate the need for bugdusting facilities or labor.

Long bars are a distinct advantage in machine loading, since the more tons per fall the fewer the time-wasting moves the loader has to make. Cutting with a long bar, however, requires greater operator skill and increases the risk of striking

Practice Trends

RUBBER-TIRED UNIVERSAL MACHINES taking over more and more of the cutting load. Bar length increasing.

MULTIPLE-PASS CUTTING coming in to increase tons per fall and loadability with no bug dusting, less power and less strain on the cutter.

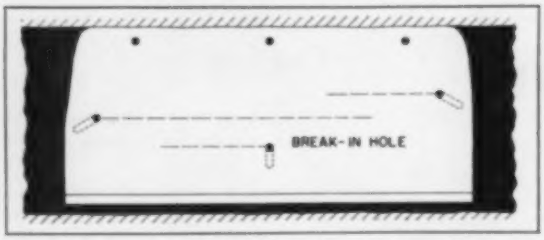
HAND-HELD DRILL use upped by development of flexible-shaft and hydraulic-powered units.

MILLISECOND DELAY shooting increasing.

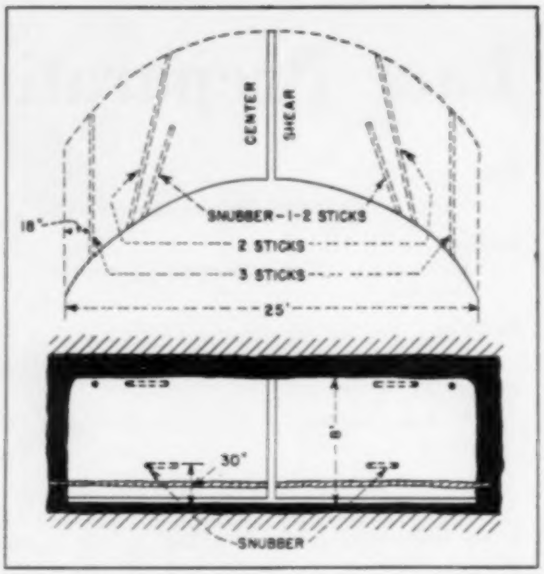
Operating Reports

Air Breaking—New-type air-breaking tube and central compressor station serves mine in 46-in coal with 2- to 14-in binder. *Coal Age*, July, 1956, p 65.

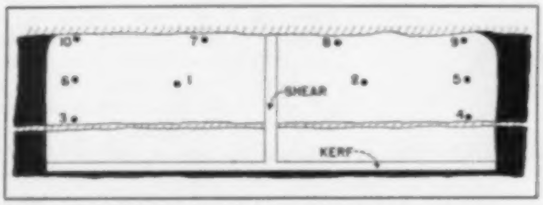
Bit Maintenance—Illustrated step-by-step rundown of bit grinding and maintenance, supplemented by a discussion of the benefits. *Coal Age*, July, 1957, p 71.



BREAK-IN-HOLE provides additional free face for relieving succeeding holes. In this plan, rib holes are stepped up to break lower part of face in section.



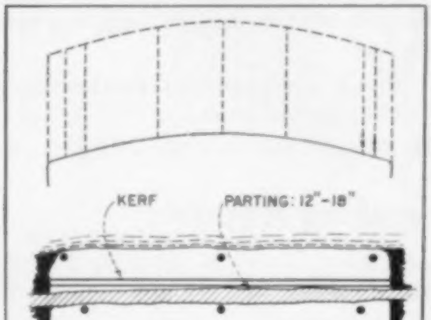
SHORT SNUBBERS break band and roll out front of fall in arc-cut center-sheared place. Shearing and snubbing reduce the number of holes required and also cut explosive requirements.

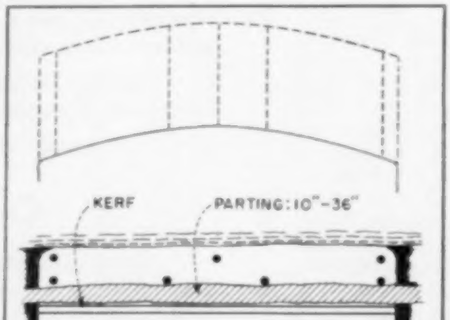


EQUALIZED BURDEN is the goal in this drilling pattern in a center-sheared place, thus achieving good breakage of both coal and impurity band.

PROTECTION against damage or loss is necessary with modern cutting and drilling bits. Left photo shows locked cabinet for preventing loss and mishandling. Cabinet has a compartment for each section's supply. Right photo shows wooden bit holders in lunch boxes carrying section numbers for easy handling.

SAFETY ACCESSORIES include galvanometer to test circuits in millisecond delay shooting—a growing practice for promoting both safety and efficiency.





SHOOTING WITH HEAVY PARTINGS. Plan at left shows cutting above the parting, followed by shooting of the bottom bench first. Plan at right, for still-thicker parting, shows cutting underneath the rock and holes immediately above.

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undulations in the bottom and top, as well as the risks of fouling and binding. If they replace shorter bars on an existing machine, care should be taken to make sure that the motor can carry the extra load, either as is or with improved insulation.

Cut Positioning

Simplicity, ease and custom are behind the preponderance of undercutting, which has the further slight advantage that the fall helps to break up the coal. However, it normally necessitates shooting against the top and thus, where this results in serious deterioration, has led to top cutting. Cutting at other horizons may be done to get into softer zones, but usually is adopted to remove bone or rash. Where the latter is the goal, two or three cuts may be taken—or one regular cut may provide enough loosening and relief so that most of the remaining material can be raked out.

BENCH MINING—Cutting under a middle parting in thicker coal may be done as one step in bench mining, the lower bench being shot up and loaded, followed by dropping and disposing of the parting, and shooting and loading of the top bench. Very infrequently, cutting may be done in rash or soft clay under the seam, or in soft material above, either to keep the kerf out of the coal or to eliminate hazardous or troublesome top material. However, such selective mining is on the decrease and the trend today is toward full-seam extraction, including, in some instances, top stone or drawslate. This system relies on mechanical cleaning on the surface for removal of the impurities, since it normally results in a lower overall cost.

Special goals in cutting include raising the undercut where the bottom is soft to provide a good coal pavement for the operation of shuttle cars and other equipment.

Three-Pass Cutting

A new system that has found a number of advocates is cutting in three stages. The goals are maximum tonnage without sacrificing good loadability, and also without having to bugdust each cut manually. The sequence is:

1. Sump full length (9 ft) at the right, then pull out to 5 ft and cut completely across.

2. Resump halfway across to the full depth and cut the second pass to the left rib at a level that will increase the height of the original kerf around a third or a half.

3. Resump again at the right rib with the heel of the bar elevated 10 to 12 in and cut to the center, tailing out to the left to withdraw the bar. Elevating the heel of the bar facilitates cleaning the kerf and keeps the cuttings from being carried back.

Benefits include a substantial increase in tons per cut, reduced loading time, lower power consumption and less wracking of the cutter.

Shearing

The vertical cut, or shear, provides an additional free face, or faces, and is highly valued by many operators as a means of reducing explosive consumption, raising coarse-coal yield and increasing loadability, even though it does result in more bugdust. In permanent headings, some operators have sheared booth ribs to keep them free from shooting shock and thus postpone and reduce falls and sloughing.

Since shearing takes time and, as noted, increases the output of cuttings, shear cuts normally are limited to one—usually at the side in headings or other narrow openings, and between one-third over and the center in rooms.

Drilling

Match drill to the job; choose auxiliaries, such as augers, on the basis of performance.

Depending upon conditions and personal preference, operators have a wide choice in drilling equipment, including not only pneumatic equipment but also hand-held, postmounted and mobile units. The latter may be designed with one or two arms, with the hydraulic auger drive now coming to the front for greater capacity and flexibility. Hydraulic drill positioning frequently can release one man from the crew for other productive work.

Hand-held units driven either by flexible shafts or hydraulic motors are a relatively recent addition to the types of drilling machines available and in some instances have successfully challenged even large mounted units. Light weight, high speed and operation from the cutting machine through either a mechanical or hydraulic takeoff are among the secrets of the machines' success. Where the cutters do not have a hydraulic system, certain operators have found the drill benefits sufficiently large to warrant installation of a special portable hydraulic power unit.

AUGERS—The "conveyor" auger or approximations thereof now has taken over to a considerable extent from the old twisted auger in coal drilling. Advantages include greater rigidity, with consequently less whip, and more resistance to bending. These features are especially valuable with hand-held flexible-shaft or hydraulic drills, where whipping or a bent auger is especially noticeable. Better hole cleaning also is an advantage, particularly where large holes are necessary.

Better cleaning of wet down-pitching holes may be attained by changes in scroll-pitch—usually an increase.

Shooting

Choose breaking medium carefully to fit conditions and give the size consist desired.

Study the job carefully to get the best hole pattern.

Stem carefully.

A wide range of explosives and several breaking devices are available for the operator's choice in coal breaking. The breaking devices include carbon-dioxide, air and chemicals, all basically relying on building up pressure in a tube against a disk which ruptures at a certain limit to release the gas or air and break the coal. Air is the most-used non-explosive breaking medium, and the practice for some time has been to supply it from central stations on the surface, sometimes supplemented by large portable or semiportable units underground at strategic points throughout the mine.

As a rule, carbon-dioxide, air and chemical breaking require a greater number of holes because the maximum force is less, though some operators get by with no increase and many with only a small rise in number. Any increase or other extra expense normally is more than offset by an increase in coarse-coal yield, or by other benefits, including ability to break coal on shift where all other shooting or breaking is forbidden by law or regulation.

To get the effect of a slower action with powder, some form of "cushion shooting" may be employed if other conditions are favorable. The air space around the charge may be secured by increasing the size of the hole or by placing the charge or stemming to leave an air space ahead or behind. Caution must be exercised to see that cartridges are not separated, thus setting up conditions favoring possible misfires.

Hole Placement

Shooting patterns are almost as numerous as coal mines. Normally, the best pattern for any mine can be determined only by careful study and considerable experimentation. One basic principle is

(Continued on p 99)

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Roof Control

ROOF SUPPORT is almost always required in coal mining, either to protect main openings for the life of the mine or production places from falls that would endanger life and equipment and hamper production. This results from the fact that as openings are made in coal removal, the equilibrium of stresses is upset. The unsupported weight of the top results in a tendency to sag. This sagging continues until failure occurs unless (a) support is provided to prevent such failure or (b) the strength of the rock is such that it can support itself after the sag reaches a certain point.

In addition to the possibility of complete loss of the working place, removal of the coal also involves the possibility of falls of loose material. Roof support therefore is required in coal mining for two reasons:

1. Protecting men—and facilities—from falls, crushes, bumps and other top, face and rib failures.

2. Keeping working places, including entries, open for the desired length of time, which may range from only hours in pocketing through a pillar with a continuous miner up to as much as 50 yr or more for entries and airways in especially long-lived properties.

Achievement of these two primary goals also means achievement of certain collateral objectives, including:

1. No interruption of haulage, travel and other operations. Obviously, a heavy fall on the main line can shut down a mine completely, aside from the cost of cleaning up and timbering or retimbering. Even with light falls there is a penalty which, if falls occur with some frequency, can total a considerable sum in the course of a year.

2. No blocking or partial blocking of service openings, such as, airways and drainways.

3. The achieving of these goals at minimum cost. Support cost is such in many mines that even a slight change in the direction of economy can save several cents per ton.

Roof Action

Know and understand the various types of roof action as the best approach to the problem of efficient, economical support.

The roof-support problem in coal mining varies with, among other things, the type of top. Really good top is exceptional, while poor is becoming more common. The material of which the roof is made up is of course a major factor in its strength. Clays are the villain it is now believed, since investigation leads to the tentative conclusion that where they are present and are saturated with water the roof is likely to be weak. Mine roof rock usually is water-saturated.

Support varies with the objective, and also with the character of the material over the coal. For example, temporary protection against drawslate will require one type of support, while another type will be more suitable where both the drawslate and all the overlying material must be held. Still others will be better suited to permanent openings in bad top or caved ground. Weathering as a result of changes in temperature and moisture content of the ventilating air may warrant sealing the top, which is "support" in another guise.

In no instance, however, is it contemplated that the support provided by the original coal bed be replaced by support that will keep the roof in its original place and state after all the coal to be mined is removed. Even "permanent" support means only support until mining is completed. Between the time the coal is first opened up and the final pillars are removed, therefore, a number of roof conditions and roof actions may be encountered—some at every mine and all at some mines. Among them are:

1. FALLS OF IMMEDIATE TOP—These result, among other reasons, because the top material is inherently weak, such as, drawslate or clod; because of cracks and cleavage planes; because of the presence of kettlebottoms, slips and the like; because of weathering; and as a result of such mining operations as pillaring. Such falls constitute the majority of the "accidental" type, and are the ones causing most of the injuries and fatalities, most of the operating interruption, and most of the cleanup expense.

During 1956 the typical falling rock was 13 ft long, 11 ft wide and 2 ft thick. Some 75% fell within 25 ft of the working face, where 4 to 10 men customarily worked. The possibility of such falls is the major reason for emphasis on ample timber installed according to a fixed plan, and on the use of safety posts, jacks and bars in the face working areas.

One question with thin, relatively weak roof layers over the coal is, "When to take down and when to leave?" Sometimes the material is so weak and crumbly that the question becomes academic, since there is no practicable way of keeping it up. Roof-bolting with channels, bars and short headers or capboards has made it possible at times to support top that otherwise could not be handled and which, when thick enough, rendered mining doubtful or impossible because of cost, hazard or both.

Depending on coal price, seam thickness and volume to be handled, a certain thickness of top material can be taken with the coal in room and pillar work. However, when this thickness reaches 6 in or more, the chances of economical production are considerably reduced if not completely eliminated. The rule, therefore, is to hold top material in working places, especially since support commonly is necessary for other purposes. There are exceptions, of course, to meet special conditions. In permanent or semipermanent openings, the answer is "Yes and no." One of the conditions, for example, which might lead to a decision to take top is a weak or crumbly drawslate over which is a good slate or sandstone. To save lagging of the slate, cleanup later on or both, the

top would be taken to the hard material in installing support.

2. RIB AND FACE FALLS—An alternative form is sloughing, which may be defined as minor face and rib falls, with spalling a minor form of sloughing. Rib and face falls also are of the type classed as accidental. Under certain conditions—thick, pitching coal, for example—such falls represent a real hazard. Sprags against the face and posts with plank stringers or lagging along the ribs are among the safeguards.

3. SQUEEZING—In its commonest form, squeezing is the slow increase in weight on pillars or solid coal eventually resulting in such things as crushing of the coal, heaving of the bottom and the driving of pillars into soft floor or top. The cause normally is leaving pillars or other support which, after considerable area is opened up, proves to be inadequate, permitting the top to settle gradually with transfer of the weight to active places and solid coal. Most old-timers maintain that once a real squeeze starts nothing will stop it until settlement and readjustment are complete.

An alternative to squeezing is sudden collapse, which may also occur after a period of squeezing. Like squeezing, sudden collapse is rather infrequent, but it does occur, especially where thin room pillars customarily are left, or where a strong member in the top results in the creation of a large open area without a fall in pillaring. One of the effects and one of the several hazards is the ensuing air blast which, in the magnitude some times attained, in addition to wrecking doors, stoppings and other structures, can knock cars off the track and throw people around sufficiently hard to cause severe injury or death. Preventives include ample pillar area and careful attention to getting initial breaks quickly.

4. BURSTS OR BUMPS—These are the sudden, explosionlike failures of coal as a result of internal stress caused by weight. In most instances, conditions conducive to bumping include heavy cover with strong members and especially a strong member close to the coal; a point at which weight and stress tend to concentrate, as the apex of two converging pillar lines, a barrier pillar sticking out into the gob, and so on; and a strong floor. As noted elsewhere in this "Deep-Mining Guidebook," drilling and augering can be used to trigger bumps or unload stress before it becomes too great. The basic line of defense, however, is adjustment of the mining plan to prevent stress buildup. Some suggestions are:

Get all the coal. Clean out timber also, since leaving props and cribs can help set up conditions conducive to bumps.

Mine pillars as fast as possible—at an even rate. The quicker pillars can be mined, the shorter the period of time for stress development.

Orient the pillar line with the natural fracture system of the roof to promote caving in the gob, thus preventing the formation of long roof spans. If long spans cannot be avoided, some means of support should be provided to prevent breaking. Cribs are an example.

Keep development out of abutment or stress areas next to pillar lines and gobs, and develop for new pillars away from rather than toward such areas.

Adjust mining to prevent the formation of points on pillar lines. Keep lines even—no projections into the gob area.

Keep pillars as large as possible to reduce the chance of failure under stress. Uniform size and shape keeps stress even and prevents concentration on certain large or odd-shaped pillars.

Mine individual pillars open-end where possible and keep lifts fairly narrow.

5. INTENTIONAL CAVING — Since caving relieves the remaining coal of weight—at least in substantial measure—and thus eases the job of mining and support where pillars are removed, much of the roof action in mining is intentionally induced. A common goal is a fall each time a lift is taken off a pillar, and

Practice Trends

QUANTITY AND QUALITY of support per ton of output steadily increasing.

MORE EMPHASIS being placed on design of bolting and other support systems to cut the cost of supports while still providing required protection.

RECOVERY of both timber and bolts being increasingly practiced where conditions permit such recovery with safety.

SPECIAL EQUIPMENT and plans being evolved to provide support in continuous mining without interrupting production.

Future Possibilities

INCREASED USE of European-developed types of steel posts and supports.

INJECTION BONDING of roof strata together to increase the strength of the roof beam.

Operating Reports

Bolting Formulas—USBM-developed formulas for calculating bolting results. *Coal Age*, August, 1956, p 85.

Checking Bolting Results—How to ascertain plug position, torque requirements and holding power of bolts. *Coal Age*, September, 1956, p 92.

Holding Top at the Face—Top characteristics; coal, timber and bolts as supports; installation for maximum effectiveness. *Coal Age*, November, 1956, p 77.

Bolting With Truck-Mounted Drills—Mounting two bolting units on crawler truck results in an increase of 60 to 70-tons per section per shift. 45-in average-height coal. *Coal Age*, April, 1957, p 74.

Shearing-Type Bolt—Proposed new bolt has shearing head to insure automatic tensioning; also, industrial-engineering approach to bolt length. *Coal Age*, August, 1957, p 80.

Roof Bonding With Resin—Test work by USBM indicates that epoxy resins with hardeners can be easily injected into the roof and have good possibilities for converting it into a high-strength beam. *Coal Age*, January, 1958, p 116.

MOBILE TIMBERING MACHINES cut cost of adequate face support while facilitating adherence to standard plan.

HAND-PUMPED HYDRAULIC LIFTER here eases job of replacing heavy set. Truck mounting facilitates movement.

this goal is fairly easily reached under conditions ordinarily encountered. Thus, support is provided to (a) break the top at the edge of the new lift and (b), with other support as necessary, to hold the top within the lift and keep it open.

Roof action in intentional caving commonly takes place in two to three stages. The first, or initial, break snaps the roof off at the breaker line. The cave commonly extends 25 to 50 ft up into the main roof. This is followed by a secondary cave spanning several of the initial caves, and extending up to, say, 150 to 300 ft. If this is not sufficient to take the action to the surface, a third cave and general settlement normally occurs. Usually it is of sufficient magnitude to reach the surface unless the cover is exceptionally thick. Where subsidence is limited by packwalls or some other form of support, the initial strata may be cracked as a result of bending in the slow subsidence but falls of the type encountered in complete caving are relatively infrequent. Also, roof action, aside from a gradual and limited subsidence, seldom extends to the surface.

Timbering

Match type of support to the specific job, whether permanent or temporary.

Study timber types and support methods to get the most economical support possible in relation to conditions.

Types of support in the "timber" classification range all the way from roof jacks at the face to steel, concrete and brick linings in permanent openings. Between these limits, timber includes posts, legs and bars of wood, steel and aluminum; yielding arches and rings of reinforced concrete and steel; concrete, brick and masonry columns, piers and abutments; such supplementary items as wedges, capboards, headers and lagging; and coal itself. Other forms of support, in addition to timbering, are bolting, and coating, sealing and bonding discussed later in this section.

Permanent Timbering

The goal in permanent timbering should be "permanence," meaning that life of the support, within economic limits, should match the expected life of the opening. This is not an absolute rule, however. In ground where movement can be expected for some time until the measures stabilize (longwalling, or driving gangways through previously worked ground, for example), it may be desirable to make the initial timbering job a temporary one, replacing it with final permanent timber when things have settled down.

As an example of "permanence" which is not permanent, consider the case of untreated wood with a life of around 3 yr in a haulage heading with a life of 10 yr. Since treated wood normally will last at least 10 yr, it could be considered "permanent," whereas with untreated wood the initial installation would have to be replaced at least once and probably twice, with each replacement normally more expensive than the original. The moral is that within limits it is better to spend more at the start for permanence, not only to eliminate replacement, and also production stoppages as a result of falls, but to keep routine maintenance as low as possible. When timber is installed so that it doesn't rot, fail under load, or permit sloughing and spalling, as examples, conditions are most favorable for keeping maintenance to the bare minimum.

Conversely, of course, timber or support life can be excessive—and thus excessively costly—in relation to life of opening. As an extreme example, it would be wasting money to line a 5-yr-life opening with reinforced concrete, though a sand-cement mixture an inch thick on wire might well be the thing for this particular application.

LINING—Support by complete lining is limited to rather special situations in mining. These include: soft sections of top near the outcrop in a permanent drift opening, or other soft or broken areas, as under stream valleys; and permanent long-lived openings on shaft or slope bottoms. Reinforced concrete is the old reliable in heavy-duty linings, and also provides complete sealing. Sealing with some support is provided by sprayed-on sand-cement mixtures, though support is only nominal when, say, the coating is only ¼ to ½ in thick. When applied over wire and in thicknesses up to 1 or 2 in, they provide some holding power in addition to sealing. Steel liner plates also provide sealing with a considerable degree of support, and are low in cost and easy to install, using a concrete footwall as a starting point.

GROUTING—Though not strictly lining or coating, grouting has been used to strengthen top in sections of permanent openings under, for example, stream beds where the overburden is thin and the top is rotten. Elimination of water seepage may be a secondary goal. Sometimes it is the major one, with strengthening of the top as a collateral benefit of the grouting operation.

PIERS AND ABUTMENTS—Supports of these types usually are found at pillar points where openings fork, and at other places where considerable resistance to roof movement is necessary. They may be built of concrete, with or without reinforcement, concrete or cinder blocks, brick or masonry.

YIELDING ARCHES AND RINGS—Where weight is substantial, the top is badly broken, and there is a possibility of movement of the ground in which the opening is made, yielding arches or rings may be installed. Some types employ concrete blocks put together on the keystone arch principle. Of the steel types, the latest in the U. S. (*Coal Age*, April, 1954, p 92) is the full-round with joints that slip and thus permit diameter to decrease without deformation until equilibrium is re-established.

TIMBER RECOVERY is facilitated by power winches mounted on crawlers or built onto gathering locomotives.

THREE-PIECE SETS—Probably the widest used of all forms of permanent timbering, the three-piece set—a crossbar supported on legs at each end—may range from a simple affair put together at the site up to a preframed and largely standardized set designed for heavy duty. Wood is the commonest material. As noted previously, it should be treated where life of opening is expected to exceed about 3 yr. The set also may be made of steel or may consist of wood legs and a steel bar where extra stiffness and resistance to bending are desired. If steel legs are used, they should be set on concrete piers or low footwalls for maximum stability, especially in longer-lived places.

Wood is easy to obtain and work, and the three-piece set is both flexible and adaptable. Also, it supplies the required degree of support except under exceptional conditions, in which case special concrete or timber arches are about the only answers. Legs, however, reduce clearance and can be knocked out to cause, in many instances, severe falls, aside from the fact that they themselves represent an expense.

Two-piece sets are an alternative to three-piece under certain conditions—for example in a water-level gangway in pitching coal where one end of the bar is hitched into coal or rock and the other is held on a leg.

HITCH TIMBERING — To eliminate the leg and its hazards, bars may be installed in hitches either cut or drilled in the rib. Hitch holes may be provided for each individual bar. As an alternative, holes may be drilled some distance apart to accommodate pins. Steel bars are then laid on these pins and the regular bars are placed on these stringers. Properly done, hitch timbering is permanent, especially if treated wood or steel bars are employed, and cost of installation (labor and materials) is much less than installation of a regular three-piece set. Routine maintenance and cleanup are cut to a minimum.

LAGGING—Spalling of top and sloughing of ribs are the reasons for the installation of lagging, which may be small natural round timber or sawed material. In long-lived openings lagging, like main timbers, should be treated. Lagging also provides some support, but its major function is holding loose roof material in place.

SINGLE POSTS—These have a wide use in permanent support, especially in openings where the spacing can be cut down, as in airways, manways and belt headings, or where the roof needs some support but a span of, say, car width can be tolerated. Short headers may be used to increase holding spread in tender top. As with bars and lagging, permanent posts, together with wedges and headers, should be treated.

COAL—Coal itself is widely used as a means of protecting and supporting top, though the support is chancy and not too great from the standpoint of resistance to weight. Sealing of the regular top is perhaps coal's major contribution.

Temporary Timbering

Temporary support naturally finds its widest application in the active working areas, including the working face, the room and the room entries. The major objectives are perhaps three:

1. Protecting men. The average dimensions of roof falls resulting in fatalities is given by the Bureau of Mines as: length, 13 ft; width, 11 ft; thickness, 2 ft. The majority of these falls (75%) occur in the face area inby the last permanent support, and 95%, says the bureau, are a result of human failure, meaning in turn primarily failure to install proper support.

2. Keeping workings open. The aim here is to preserve access to the face area from which production comes.

3. Holding top during pillar removal. Here, the support should have sufficient strength not only to hold the place open as long as necessary, but also to break the top at the desired point and thus help initiate the caving process.

STANDARD PLANS—The key factor in temporary support, particularly in the critical area within 25 ft of the face, is a plan for minimum support rigidly adhered to and supplemented with additional support where there is any doubt that the minimum is insufficient. The fact that nearly a third of the roof-fall fatalities occur where a timbering plan has been established is reason for emphasizing the need for supplementary support.

FACE-AREA SUPPORT—If coal is to be produced, both machines and men must work in the face area, which also means that timbering must be planned to permit reasonably efficient mining while at the same time providing maximum protection against all the hazards of newly exposed top whose condition is largely unknown.

Among the specific hazards are slips, clay veins, kettlebottoms and the like, aside from general weakness, as in the case of certain drawslates, clods and the like. Also, unless caught, certain roof members will separate and sag, thus requiring more attention than if they had been secured immediately. Swelling or

disintegration as a result of moisture are additional difficulties that may crop up in face support.

SAFETY SUPPORT—The first line of defense in face support is the safety post or safety jack. The latter has the advantage of being easier to install, as well as to move to permit machines to pass. Interference is relatively little with hand-loaded conveyors but increases progressively as mining moves toward mobile machines.

The crossbar is one logical answer to keeping support close to the face while at the same time keeping down interference. Where the coal is low, crossbarring, especially if weight sags the bars, may result in too-little clearance for mobile equipment. This has resulted, in some mines with poorer top, in conveyors being chosen instead of loaders.

Roof bolts also have the advantage, in most instances, of providing good support with maximum headroom. In many instances it is possible, by modifying the face cycle, to install them as the coal is loaded, starting for example, on the right rib as soon as enough coal is loaded to make room. In addition to independent bolting units, many continuous miners now are being equipped with dual bolters so that support may be installed as the machine mines the coal.

Face support plans are almost infinite in variations but the general routine is to extend posts, crossbars or bolts to the face immediately after loading to protect the cutters, drillers and others engaged in preparing the next fall. Roof jacks may be used to protect machine operators specifically and saddle jacks may be employed under bars to permit movement for cutting with shortwalls. Then, after shooting, the top may be caught by safety posts or jacks (or bolts) as soon as an appreciable area is exposed by loading. Thus, support is provided whenever there is an opportunity for installing it.

Protection for loader and miner operators who are relatively far back from the face, commonly is provided by bolts and/or crossbars spotted over the machine and either left in place or moved up. Use of bars of course is dependent upon sufficient height for clearance. Handling bars in the face zone, particularly where they are moved ahead each time a cut is made, is somewhat of a problem, particularly, if metal or heavy wood is needed for strength over the necessary open spans. As a result, a number of operators employ aluminum H-sections which are both stiff and light for high holding power and ease of handling. One mine, as an example, keeps two such bars in each place, moving them ahead when each cut is completed.

PILLAR SUPPORT—In addition to the regular protection of men, machines and working places, support in pillar sections usually functions as a top-breaker also. Coal itself is a form of support, either as stumps, wings, thin straight fenders, or sawtoothed fenders made by gripping or cutting out on the gob side, as examples. Frequently, a part or all of this coal may be recovered, and even if it is not, it represents a support cost considerably less than the conventional timbers or cribs. Artificial support, as in solid work, consists of jacks, posts, bars and bolts used much the same way, plus cribs and breaker timbers, both the latter primarily to break the top and at the same time protect rooms and pillar places against the riding over of caves.

Heavy weight or other special conditions may warrant special measures in roof support during pillaring operations. At one mine, as an example, the first step in mining a block open-ended is to crib it on the two sides next to the gob, supplementing this with similar cribs on a number of neighboring blocks in the section.

Overburden at this operation ranges up to 1,500 ft in thickness and the immediate top is 40 to 80 ft of sandstone. At another property, the machine operator is protected in recovery of the final corner stump at the intersection of the pillar split and room by erecting cribs on each side of the space in which the machine advances in mining the stump.

ROOM AND ROOM-ENTRY SUPPORT—Depending upon equipment and mining plan, "permanent" room and room-entry timbering starts at from one cut up to 25 ft back of the face. Usual types are posts with or without capboards or short headers, and three-piece bar-and-leg sets. With topcutting in thick coal, legs may be eliminated by gripping out with the cutter bar to form slots into which the bars may be slid.

STEEL SUPPORTS—Roof jacks until recently have been about the only substitute for wood posts in working places. Old rail has been used in the past and some attempt has been made to employ light shapes, corrugated strips and other steel members.

The advent of the coal planer and similar types of equipment brought the European-developed steel posts and steel post-and-header combinations into the picture in the United States. Their main application is on planer and slicer faces, but they are being considered in some quarters for certain other applications. Design features leading to such consideration included high load-carrying ability, provisions for yielding and thus guarding against sudden collapse through support breakage, and quick installation and release.

Timber Economics

If a place makes 25 tons and a post costs 75c to buy and the same to install, the cost per post is 6c per ton. Therefore, particularly where support recovery is not contemplated, support methods, materials requirements and possible recovery should receive intensive study.

Elimination of fatalities and injuries, and the promotion of efficient mining are, of course, the overriding goals and should not be jeopardized by stinginess in timbering. However, since even saving one post per cut amounts to considerable money per ton, a change in the posting pattern—perhaps by staggering, as an example—can achieve this saving and still provide the requisite support and protection. Where bars and other more expensive items are involved, the desirability of close study and economy becomes even greater.

TIMBER INSTALLATION — Even though it may prove impracticable to reduce the number of timbers set—particularly crossbars—substantial economies in setting cost can be achieved by timbering machines, now available in a number of types with both rail and rubber-tired mountings. The first commercial design for a timbering machine was developed over 10 yr ago, and one of the first installations saved its user 12c per ton in reduced labor for timbering and higher tons per loading-machine unit.

In addition to mobile units, small hand-operated lifts have been developed for replacement and installation of cross bars in entries and gangways. They are designed for mounting on one end of a flat-bed car or truck.

Even without special machines, the timber crew's work can be lightened and its capacity increased by the use of timber jacks to take the manual labor out of raising crossbars. And in thick coal, where universal cutters are employed, the cutter bar may be pressed into service to lift bars into place.

SALVAGE—The practicability of recovering posts, bars and other timbering material depends on (1) whether it is safe, (2) whether, as with the customary untreated material, decay has left it with little useful life, and (3) the cost of recovery. If these and other questions can be answered affirmatively, recovery can then proceed, but only on the basis that adequate temporary support be installed before the post or bar is removed, or that removal be done from a safe point.

Removal sometimes is synchronized with making falls in pillar mining. Supports may be pulled one by one from a remote point using the old-reliable hand-operated postpuller, or "sylvester." Greater economy and the ultimate in safety is achieved by pulling supports in

groups with a power winch, wire line, and chain or chains. Some coal companies, for example, have mounted motor-driven winches on old locomotives to convert them into mechanized pullers, while others have put the winches on crawler-type shortwall trucks.

Even with the best of equipment, recovery is only a fraction of the total timber installed, though a sizable one in many instances, with consequent overall reduction in cost of posts and bars. In some instances, posts and bars have been reclaimed and re-used as many as five times.

Roof-Bolting

Design the bolting pattern to give the desired protection yet keep cost of bolts and installation down.

Provide good anchorage and tension properly for maximum reinforcing power.

Check installations periodically to guard against loss of tension.

BOLTS broke into coal mining as a means of roof support in solid work. They then moved into support in pillaring and also are used to prevent heating of bottom and the sloughing or caving of coal or rock ribs in shafts, slopes and entries. Bolts, however, are not a universal cure-all for roof troubles, and conventional timber or a mixture of bolts and conventional timber may be better from all angles under certain conditions.

Bottom advantages include the following:

1. **Better support** and consequently fewer injuries and fatalities from falls. According to the Bureau of Mines, it is 5½ times safer to work under bolted top, compared to timbered. One reason is that bolting lends itself better to the development of definite patterns, and to closer adherence to the patterns after development. Clearance—either side or top—is not reduced in bolting, and there are no timbers to be knocked out.
2. **Higher output** per man and machine as a result of more working room and no interference.
3. **Less bulk in support material** to be stored, handled and transported.
4. **Better coal cleanup.** In some instances, loss of coal behind timbers is as much as 5% of the total or more.
5. **Higher extraction** as a result of good top conditions and fewer or no falls throughout life of place.

As an example of these and other advantages, one operation found that roof-bolting was directly or indirectly responsible for the following benefits:

1. An 80% decrease in accidents of all kinds.
2. A 50% decrease in resistance to air movement by eliminating obstructions.
3. An increase of 5 in in headroom.
4. A 70% increase in production efficiency because of elimination of interference and falls and other improvements in working conditions.

In some instances, all these advantages—or many of them—have been secured with an actual reduction in support cost as a result of bolting. Normally, however, bolting cost, everything considered, is slightly higher than conventional timbering, but is warranted because of the advantages enumerated previously, as well as others.

Bolt Types

Roof bolts normally function by pinning a number of weak members together to form a strong beam. A somewhat rare function is hanging loose lower members to a strong upper member. In beam-building particularly, the desired result is attained by anchoring the bolt and then screwing a bearing plate up against the top. This, it will be recognized, puts the bolt in tension and makes the beam-building action possible. Unless the bolt is tensioned, there is no beam action, and unless tension can be achieved, meaning that an anchoring stratum or horizon must be found, other means of support normally must be employed.

The object in bolting is reinforcing the roof and thus increasing its resistance to sagging and failure. If the roof is good it may be necessary to increase its natural resistance to failure only one-half, as an example, meaning that only a minimum of support is necessary. But as its natural resistance to sagging and failure decreases, the reinforcement factor increases. Thus, for top that is inherently weak, it may be necessary to install support that will multiply its natural resistance to failure as much as 3 to 4 times.

SPLIT-ROD-AND-WEDGE—Properly installed in rock of the right type, load-carrying characteristics of the split-rod-and-wedge bolt are excellent. It is easy to install and is not weakened in the installation process. However, it requires compressed air for driving and thus may require the purchase of compressor equipment. The extra step of driving the bolt into the wedge increases installation time approximately 20%, and cost of materials usually is higher. It loses its holding power more readily in the softer, semiplastic rocks and protruding bolt ends are a hazard, though they may be clipped with special bolt cutters.

EXPANSION - SHELL — Requires no driving to anchor, is better suited to softer semiplastic rocks, is normally cheaper—about 25%—and can be installed in shorter time. However, it is more difficult to tension properly, and maintenance of tension is difficult in soft material.

BOLT SIZES—The usual sizes of bolts today are ¾ and ⅝-in. The ⅝-in bolt in high-strength steel has a maximum yield load of 9,040 lb, compared to 10,020 lb for regular-strength steel in the ¾-in size. In the ⅝-in size, the weight of 100 4-ft-long bolts, rolled threads, unchamfered square heads, is approximately 350 lb. The weight of 100 of the same bolts in ¾-in size is 510 lb. Thus, with the same holding strength the saving in steel is nearly 30%.

Plates usually are 6x6 in, though other sizes are employed. Embossing can give the same bearing strength with a considerable decrease in thickness, and consequently such plates are used by a number of producers.

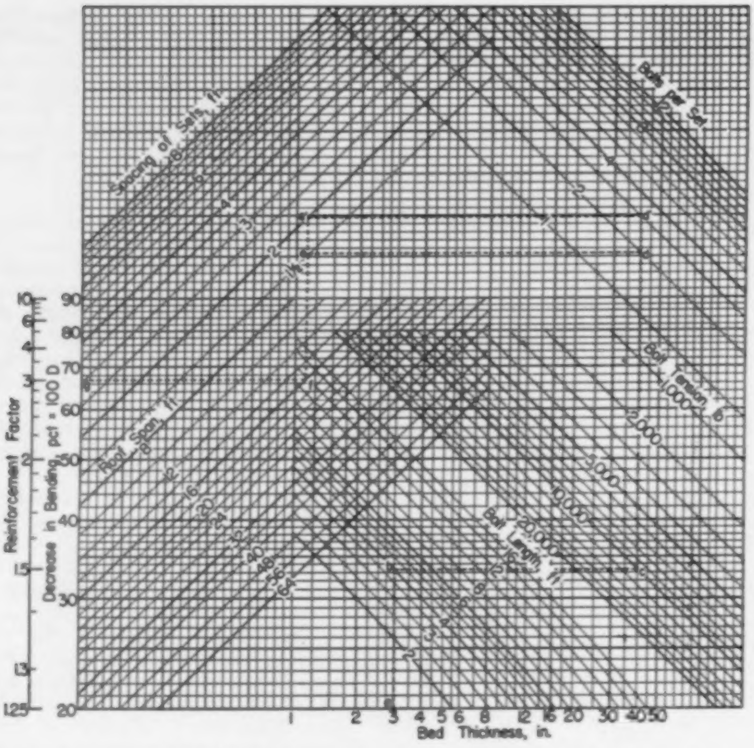
The ⅝-in bolt, incidentally, offers another advantage where tension dropoff is experienced as a result of plastic flow of top materials, movement of top strata and/or shrinkage of headers (*O-B Haulageways*, September, 1956). This reflects the fact that the ⅝-in bolt has approximately 42% greater linear deformation than the ¾-in regular. Thus, if a 4-ft bolt of each type was installed to a tension of 10,000 lb, and roof movement later reduced the stretch in each by 0.030 in, the tension would drop to the following: ¾-in, 3,600 lb; ⅝-in, 5,300 lb. The higher figure for the ⅝-in bolt might mean the difference between failure and continued holding of the top.

CEMENTED BOLTS—A recent introduction is the cemented bolt. Cementing naturally increases the cost substantially but does insure a permanent anchorage, especially in soft strata. It is offered primarily for long-lived permanent openings where the extra cost is less a factor.

The design (*Coal Age*, May, 1957, p 120) is based on the use of a reinforcing bar instead of the conventional bolt, plus a perforated sleeve. The sleeve is placed in the hole and filled with mortar. The reinforcing bar is then driven into the sleeve.

Bolting Patterns

As with timbering, the pattern with bolting must be adjusted not only to conditions at each mine but also to variations within each mine. And since an individual bolt in place seldom costs less than $2, including equipment maintenance and depreciation, etc., saving even one per cut, provided safety is not jeopardized, is a worthwile economy. By the same token, auxiliary forms of



BOLTING DESIGN CHART developed by U. S. Bureau of Mines facilitates design of bolting systems which provide the required support with a minimum expenditure for bolting materials.

support should be omitted unless they contribute significantly to holding power and safety.

Where bolts are used alone, a check of published descriptions apparently indicates that the majority are placed on 4-ft centers, compared to 4 to 5 ft with crossbars and individual posts. Special patterns for long spans or weak top include the "Star" (a bolt in the center of a four-square pattern). Also, under some conditions, making part of the bolts—say every other one—longer may be helpful.

SUPPLEMENTARY SUPPORT—Even though bolting is one of the best support systems yet devised for holding the immediate top, which is its major function, it is manifest that bolting alone is not the answer to all support problems. One evidence is the occurrence of major roof-fall disasters where bolting patterns were considered satisfactory. True, the number of such falls has not been large, but they have helped focus attention on the following points:

1. The need for auxiliary timbering in many mines to help support the top and equally or more important to give warning of impending collapse.

2. The need for careful checking to keep track of changes in roof conditions so that the support system can be modified to compensate.

In fact, in a few instances, it has been found that conventional timbering is more reliable, easier to install and cheaper, in addition to the support and warning features, plus, in some instances, increased salvage of support material.

The type of roof has some bearing on the type of the supplementary support. For instance, with a strong anchoring member not to far up but with a tender roof immediately over the coal, or one that contains slips, cleavage cracks, kettlebottoms and the like, the bolts themselves may be used as the mounts for the additional support. This additional support takes the form of wood blocks, headers or crossbars, as well as metal auxiliaries, including steel channels, steel ties, heavy wire mesh, aviation landing mats, and so on.

Where there is a question of anchorage, or where there is doubt about the strength of the beam created by bolting, support independent of the bolts may be necessary. This takes in all the conventional forms, including single posts, bars and so on, including such special types as a crossbar held by a bolt at one end and resting on a post at the other. The latter practice was developed for pillar work, the post being sent on the solid side to act as a breaker when the next lift is taken.

Designing Bolting Systems

Based on the results of model testing (USBM R.I. 5155, "Design of Bolting Systems," and 5156, "Reinforcing Bedded Mine Roof With Bolts"), the U.S. Bureau of Mines has developed a general procedure for designing a bolting system. Based on a roof-bolting design chart, illustrated, the procedure is as follows:

1. Take as a first approximation of average bed thickness a figure arrived at by dividing the observed thickness of the roof section and dividing by the number of separate laminations. Use of the average results in conservative design. Laminations thicker than the average result in a higher reinforcement factor than the chart, which applies where all laminations are the same.

2. Choose a bolt length that will assure firm rock at the anchorage horizon. This may depend upon the results of tests (Item 3).

3. Conduct tests to determine bolt-anchorage capacity (R.I. 5040, slotted-type bolts, and R.I. 5194, expansion-type). Choose as the design value for the bolt tension either the anchorage capacity or the following, whichever is smaller: 10,000 lb for a wedge-type mild-steel bolt or 8,000 lb for a ¾-in mild-steel expansion-shell bolt. However, if experience shows a significant loss of tension after installation—say to 5,000 lb a month later—this lower figure should be used.

4. Choose the number of bolts per set so that the spacing within the set (span divided by the number) is not excessive. For most mines the maximum safe distance between bolts is estimated at 4 to 6 ft. The minimum bolts per set can be determined from roof-condition experience at the particular mine. A logical procedure would be to decrease the bolts per set in steps, each time decreasing the spacing as required by the design chart to keep the reinforcement factor unchanged. Bolt-to-bolt and bolt-to-rib spacing should be approximately equal in the set.

5. Choose a trial value for spacing between sets along the opening not greater than the spacing across the opening within the sets.

6. Using the desired roof span, construct the line A-B-C-E-F-G on the chart.

7. If the reinforcement factor is less than 2, decrease the set spacing and/or the roof span, and increase the number of bolts per set and/or the bolt length. A change in spacing and/or span will have a greater percentage effect.

Results achieved in bolting a particular roof should indicate whether the existing reinforcement factor, as determined from the design chart, is adequate or should

be increased by modifying the existing bolting system. In the absence of previous experience the minimum reinforcement factor should be 2; otherwise bolting is not justified. Conversely, if the existing bolting system is judged to be effective, the design chart may be used to develop a system that is less costly.

Bolt Installation

Split-rod-and-wedge bolts require a percussion tool for installation, which in turn requires compressed air. Since bolts of this type were the first to be developed, air was the first bolting medium, being used both for drilling and driving.

Air still is the preferred medium for drilling the hard rocks encountered in mine roofs, even though electric rotary drills have been taking on harder and harder material. Portable compressors are widely used, though central stationary units have their advocates, who state that the advantages include plenty of air at rated pressure, lower maintenance and less trouble with dirt and water in air lines.

Portables may be mounted on rubber or crawlers, or may be carried in shuttle cars. They may be sized to operate one or two stopers, but in any event they should be capable of supplying drilling needs without drop below rated pressure.

ROTARY DRILLING – Development of the expansion-shell bolt put the rotary drill very much into the roof-bolting picture. Now a wide variety of machines are available and they are being built for harder and harder rock, though they still cannot cope too well with the hardest types.

Ability to vary speed and pressure is a very desirable drill characteristic. In soft drilling, high speed and low pressure usually give the best results. In hard cutting, reducing rotational speed and building up pressure results in better cutting, especially with the proper design of bit head.

Length of drill should be as short as possible for maximum strength. Ejection of material in rapid drilling may make the use of a conveyor-type auger desirable. Spiral flights may also serve another purpose, i.e.: eliminating the offsets which tend to occur when passing from soft to hard rock, with subsequent breakage of bails as the bolt is run up. Spirals almost the diameter of the hole prevent this occurrence.

Proper operation and maintenance of rotary and other type of roof-bolters have a significant bearing on costs and results. If possible, the manufacturer should be afforded an opportunity to explain the operation of the machine to the maintenance superintendent, foreman and driller, with special attention to showing the driller the relation of thrust and rotation to penetration and bit wear.

Regular inspection, proper lubrication and cleanliness are basic approaches to the problem of keeping maintenance down. Also important is having the maintenance superintendent and manufacturer determine proper pressure adjustments. Pressures should be checked regularly and should be adjusted for changes in roof conditions.

Bits–Drilling with dull bits results in overheating and damage to the bits, in addition to damaging machine parts because of excessive stresses. Bits ground off-center or with one short cutting lip result in hole enlargement, making proper anchorage impossible in some materials. The same effect also results from allowing bits to spin or "dwell" too long at the anchorage horizon. Worn bits, loose-jointed drill extensions or drill whip can result in undersized, "dog-legged" or rifled holes.

Bit type and care thus become important items. Recommended steps include:

1. **Work with bit manufacturers** to get the proper carbide and design.
2. **Consider the use of two or three sizes of bits** to reduce wear through loss of gage and speed up drilling.
3. **Match thrust and rotational speed** to conditions for maximum penetration and minimum bit wear.
4. **Employ trained men** for sharpening and reconditioning bits.
5. **Keep a bit-sharpening record,** and a record of holes drilled and bits lost or destroyed.
6. **Determine bit needs** per shift, all sizes.
7. **Provide driller with two strings of bits** so that while one string is in use the other can be sharpened.
8. **Use bit record** to determine if the machine needs adjustment, roof conditions are changing, or the driller needs instruction.

DUST COLLECTION–Of the two main methods of suppressing dust–water during drilling and dry collection –the latter is forging ahead because of the inherently greater complications of water. The simplest form of dry collector consists of a flexible collar held against the roof to collect the cuttings and drop them into a bag or onto the floor. More positive means of collection and disposal are provided by vacuum units operating through collars around the drills or, in the latest, by pulling the cuttings through hollow bits and drill steel.

Dry dust collection, however, has been found inadequate under some conditions though normally it is generally preferred. Drilling in hard sandstone at one operation, as an example, became impracticable with dry collection. Tanks and pumps were installed to feed water up through the hollow drill rod, making it possible not only to drill the rock but rendering dust collection unnecessary.

ANCHORING AND TENSIONING –Anchorages vary in accordance with the type of rock, with corresponding effect on the maximum tension possible. And without anchorage there is no possibility of achieving tension and consequently there is no reinforcing effect. Naturally, other things being equal, a better anchorage can be achieved in hard sandstone. In fact, in such material it is possible to break the bolt before it pulls out. In soft shale, the opposite is the case and the bolt will pull out before it will break. However, a certain degree of tension can be achieved even in soft material and this frequently is enough for the purpose, or enough to reduce the need for supplementary timber.

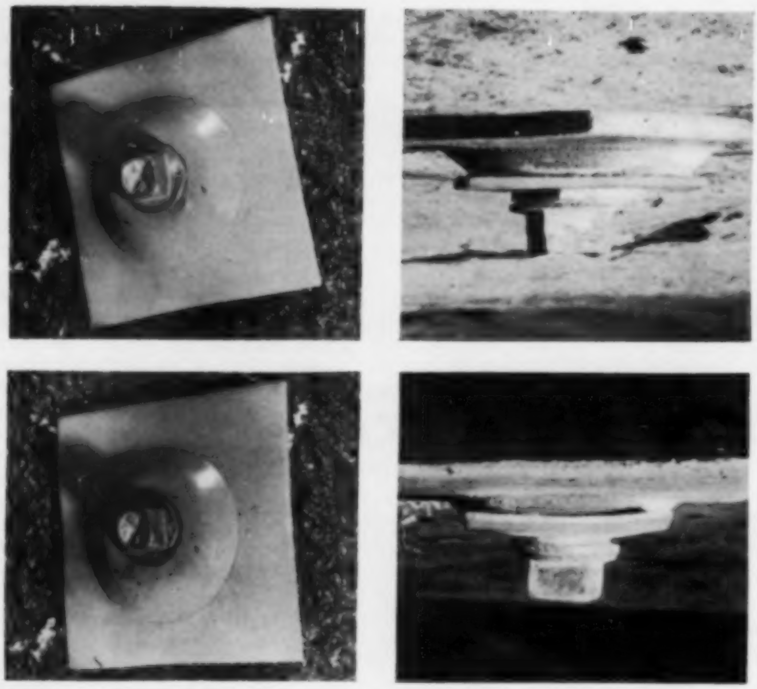
Correct hole size is a major factor in good anchorage and ability to tension properly. Undesirable variations include oversize, undersize, "dog-legging" and rifling. Periodic checks with a hole gage is a major method of revealing such faults before they become serious enough to cause trouble.

Proper installation is another factor in good anchorage. With expansion-shell types, this includes positioning of the expansion units so as not to use up thread and thus increase the possibility of not being able to develop full tension because of running out of thread. Check plug and shell position periodically by removing sample bolts to see that proper anchorage is being achieved.

CEMENTED ANCHORAGE–A new development in anchoring expansion-shell bolts is enclosing the shell in an envelope containing a quick-setting plastic cement. As the bolt is run up the envelope is punctured and the cement fills the hole and hardens for a firmer anchorage in any type of top.

TORQUE REQUIREMENTS–Under average conditions, 50 to 80 lb of tension is developed for each foot-pound of torque. If 60 is taken as a conservative factor, about 150 ft-lb of torque will develop 9,000 lb of tension–well below the yield point of a ¾-in mild-steel or ⅝-in high-strength bolt, assuming the bolt bears against a plate that is level and that there is not excessive upward pressure to generate additional friction.

Torques up to 200 ft-lb may be employed in hard material, with some authorities suggesting around 170 ft-lb



VISUAL EVIDENCE of bolt tension is provided by new indicators. The type at the left shows by flattening of the crimp in the washer when proper installation tension has been reached. The type at the right (flat at proper tension) also shows if bolts have lost tension after installation by flipping back to original shape.

in hard shale and 150 to 160 in soft shale. In very soft top, where anchorage capacity is limited, bolts may be tightened with a hand torque wrench to determine the suitable setting for the bolting machine.

Bolt head and roof plate should be firmly against the top before tightening begins to make sure that the maximum thread length is available. Excessive torque may be wasted in hard top as a result of galling between bolt head and plate. If the plate is not level the bolt head may be twisted off at over 175 ft-lb.

Caution should be observed with wood headers to make sure that tension is preserved. Wood can dry out, yield under pressure and otherwise change characteristics with loss of tension. Never install a wood header, crossbar or capboard with a nut alone. Always use a steel bearing plate.

Other factors involved in good anchorage and tensioning include machines in good adjustment and the use of the correct bolts, shells and washers for the job.

CHECKING TENSION—The ultimate in accuracy and perhaps the best method of determining the efficiency of the bolting job is the pull test with a hydraulic ram. Between such tests a hand torque wrench should be employed at frequent intervals to check the accuracy of the torque setting of the wrench or bolting machine.

After installation bolts may lose tension for any of a number of reasons, including plastic flow of the rock at the anchorage point, movement of the strata, drying out or yielding of the headers, crumbling of protuberances under the bearing plate, and so on. As noted, the handy device for spot checking to see if a tension dropoff warrants retightening is the hand torque wrench.

VISUAL INDICATORS—Two general types of indicators to show tension in bolting are now available. One shows only that initial tension is secured, and consists of a crimped washer, the crimp of which disappears when the correct tension is released.

The second type shows not only that initial tension has been secured but also if any relaxation takes place in service. Such indicators, because of their cost, normally are designed for installation on approximately every 10 or 12 bolts. One device of this type consists of two circular plates between which a layer of rubber has been bonded. As the device is placed under tension of compression the rubber expands or contracts, and the relationship between tension and torque, or the relaxation of tension in use, can be determined by using a special compression-pad gage.

The second indicator comprises specially forged self-centering-head bolts, specially embossed plates and concave steel-spring washers. They change shape as the load is applied and change back when tension drops to a certain value.

Concurrent Bolting

Continuous miners, since they are designed to stay in one place all or most of the time, have presented some problems in attaining the benefits of bolting, as well as problems with conventional timbering also. These problems have been accentuated with the growth of conveyor transportation, which further limits the opportunity for using separate bolting facilities.

Concurrent bolting is one answer, and bolting units have been devised for installation on all types of miners, whether ripper, semirigid head or boring type. The mounts normally permit angling the drill in or out a maximum of 25 to 30 deg. The usual practice is to swing the unit out on one hole and install the bolt, and swing it in on the next, thus getting two rows on each side of the place, unless only one row on each side will suffice.

The key is sufficient speed in bolting to permit the job to be done before the machine has to move, if it is of the ripper or semirigid type, or until it advances beyond the slide or arm range of the unit on boring types. Normally, sufficient time is available to permit a good job of bolting, which can practically eliminate stopping the machine to install supports. The additional production can be as much as 20 to 25% where such bolting is possible. In addition, no member of the crew is exposed to open top with some types of installations, and only the bolters with others. Even then, the bolters are some 12 ft or so back from the face.

Bolt Recovery

Since, as with timbering, except on pillar lines, it is estimated that not more than one bolt in 10 is ever called upon to actually support top material, salvage almost automatically becomes a matter for consideration, since whether the bolt is holding top is a major factor in determining whether recovery is possible. Even if most of the bolts were supporting top, salvage would still be possible by installing protective support, but the hazards are substantially greater and the savings possibilities correspondingly less.

Recovery operations so far are limited almost entirely to the expansion-shell type of bolt. Under favorable conditions, recovery cost is ¼ to ⅓ the cost of a new unit, including expenditures

for new shells and nuts to go with bolts and plates that have been salvaged.

Hand salvage is the rule, and a basic principle is setting roof jacks or safety posts before any attempt is made to remove a bolt. A second principle is at least two men to a salvage crew, since two heads can be better than one in guarding against hazards, and the second man, in case of trouble, can, in many instances, prevent an accident from turning into an injury or fatality. Experience so far indicates that a two-man crew can recover 200 to 300 assemblies in a shift.

Mechanized recovery units have been developed for some operations. In one, a standard drill with appropriate socket is installed at one end of a rubber-tired truck with the operation switch at the other. Thus, the men are back of at least two rows of bolts when removal takes place, and consequently do not need to set as many safety jacks or posts. With two men, it was reported, recovery was running 300 bolts per shift. No recovery is attempted under bad or doubtful roof. After the drill loosens the bolt, it is pulled out by means of a piece of copper tubing about 6 ft long.

Continuous-Miner Plans

Make sure that operator and other crew men are under supported top at all times.

Design the support system to keep operating interruptions to a minimum or eliminate them entirely by, for example, concurrent bolting.

The continuous miner, as previously noted, presents some tough problems in achieving support without interruption, and these problems are accentuated when conveyors are used for transportation. In return, however, certain miners contribute a benefit in the form of arched or elliptical openings which definitely increase the resistance of the top to sagging and failure.

Unless concurrent bolting is practiced (see previous material on "Bolt Installation"), interruptions in the operation of the miners are almost inevitable if the operator is to be protected at all times by support. Consequently, the usual practice is to advance full-face machines to the point where the operator is under or only slightly beyond the last support, whether it be bolts, posts or bars. This means that the usual advance is 18 to 20 ft, after which the machine is moved back and the newly exposed area is timbered or bolted. An alternate place or places cuts down on the loss of time if the moving distance is not too great.

Concurrent timbering, in addition to concurrent bolting, is being developed to prevent waiting or moving. Posts or posts and bars are installed in conventional fashion in cycle in the usual system. Special systems, however, include hitching on one side and supporting bars on posts on the other. In one instance, a boring-type miner was equipped with cutters making a 6-in slot 18 in deep on the hitch side to accommodate 4x4 H-beams 15½ ft long, using a post and wedge at the opposite end.

If the machine is not a full-face unit, the practice is to alternate advance from one side to the other. If a full-width cut is taken on each side it sometimes is feasible to bolt one side while the other is being advanced. Adjusting length of advance to bolting time makes it possible to synchronize so that the miner operator is never out from under protected top. If the place is being cut only head width, or width-and-a-half, it usually is necessary to stop and pull back or move to another place to permit bolts or timbers to be installed.

Bolts usually are placed on 4-ft centers with continuous miners; bars on 4- to 5-ft centers, where used. If single posts are employed, they usually are set in a row or rows equally spaced from both ribs, leaving a roadway in the center. With certain types of miners recessing of bolt heads and plates into the top is being practiced at some mines to keep them from interfering when a crosscut or pillar place is started.

Where only rooms are mined, some operators use the adjacent place as storage for bars, props and jacks. One, as an example, uses jacks and bars, picking them up from the preceding place as each crosscut is reached.

In pillar extraction, conventional bolting or timbering plans can be followed where pockets are driven and stumps are left against the gob for final recovery or crushing. In open-ending it may be desirable to adopt a special plan. One, for example, more suitable for full-face units, involves cribs and breaker posts to protect the open lift until extraction is completed. Another is based on bars bolted at one end and supported on a post or posts at the other—usually next to the gob. This system it will be noted, would be more adapted to ripper-head or to other non-full-face units. Or, the latter procedure might be reversed to put the posts on the solid side so that they could serve as part of a breaker installation for the next lift.

Even though support is more complicated in continuous mining, such mining has so far proved to be far safer mit bolts or timbers to be installed.

Coating and Sealing

Consider for protecting certain roofs in certain areas against the adverse effects of moisture and temperature changes.

The susceptibility of certain types of roof to changes in moisture and temperature is so pronounced that a number of deep mines in the past have installed elaborate conditioning units to insure uniform humidity and temperature. More recently, even though the idea is old, a number of operators have turned to coating and sealing to prevent roof and rib deterioration as a result of these influences.

Coating and sealing products include vinyl compounds, coal-tar products and mastic-type materials—all sprayable with or without heating, usually because they are dissolved in a volatile compound which evaporates after application. Because solvents normally are flammable or explosive, or both, care must be taken in application. Also, care must be exercised to see that after application the material will at least not propagate fire even if ignition cannot be prevented. A number of products now on the market meet this standard and are being employed.

Careful scaling and dryness are major prerequisites to good sealing. Though it provides no support, sealing has cleaned up some very costly roof and rib disintegration situations at a number of mines where conventional timbering failed to do the job. Cost varies from 15c to 20c per square foot minimum at most operations, including scaling and other preparations. Usual practice is to seal the top and carry the coating 6 or 12 in down each rib for insurance. At some mines, all the coal ribs are sealed to prevent sloughing. One of the incidental benefits is a smoother surface, which helps ventilation.

Injection Bonding

The major objective in bolting, as previously noted, is binding several thin, weak layers together to make a thicker, stronger roof beam. In essence, the process is the same as making plywood, which logically led to the idea of bonding roof members together much as the plies are glued together to make plywood.

The bonding is done by injecting the bonding agent under pressure through drill holes at appropriate intervals and of appropriate depth. Experiments so far (*Coal Age*, January, 1958, p 116) indicate that the idea has good possibilities. If further work confirms this, bonding may be the new and more-efficient approach to reducing or preventing roof falls.

with belts, then the change to 100% AC

Transportation

THE FUNCTION of transportation is to move coal from the face as fast as the loader can load it or the miner can mine it, and keep it moving to the preparation plant on the surface without interrupting loading or mining. This means that the transportation system should always be in place and ready to carry coal anytime loading is in progress. Furthermore, the system should have capacity to handle any peak the loader or miner is capable of reaching. Finally, the system should operate with a minimum of manpower and maintenance.

COST-CUTTING POSSIBILITIES – The savings provided by modern transportation facilities are alone worth a substantial investment, aside from their effect on face performance, as two recent examples show:

1. Replacement of 1,500 old mine cars (2.9-ton payload) with 505 new 9.6-ton units, 7½-mi average haul. Result: 33% cut in haulage costs and 5% in overall cost of coal in the railroad car. The investment will be returned in 2½ to 3 yr.

2. Increasing use of belt transportation from 17% of the coal handled in 1952 to 55% in 1958. Result: haulage cost reduced from 31c per ton in 1952 to 20c in 1958 in spite of increases of $5.90 in wages, $80 in vacation pay and 10c in welfare-fund payments.

Practice Trends

TORQUE-CONVERTER and straight AC shuttle cars cut investment and operating costs at the face and bring full AC mine operation appreciably closer.

EXTENSIBLE CONVEYORS continuing to work up rapid gains in serving face units.

AUTOMATIC TRIP-MOVING and loading stations becoming more numerous.

BIG CARS and locomotives continue to take over in rail haulage.

ROPE BELTS continue to gain at a rapid pace in the conveyor-haulage field.

PORTAL RELOCATION increasingly practiced to cut travel time and add to efficiency in handling men and supplies.

Future Possibilities

DIESEL MAINLINE HAULAGE to clear away the last obstacle to complete AC mining underground.

TROLLEY CONVEYOR or other new types for mainline haulage.

PUMPING OF COAL from face to preparation plant.

PNEUMATIC or hydraulic hoisting of coal.

Face Haulage

Aim for the maximum degree of continuity by the use of continuously operating equipment or by use of the largest possible mine cars or shuttle cars, plus layouts which keep changing time to a minimum.

Although mine cars have moved into a minority status in serving face units, some of the lessons learned in attaining maximum efficiency with them apply with equal force to their successors. One lesson is use of the biggest car possible to cut down the number of changes and thus increase loading time. A second is a haulage layout providing at the best a changing point no farther back than the next crosscut, and at the worst no farther than 150 to 175 ft back. One contribution to the short change with cars was the development of prefabricated track layouts, which practically guaranteed a changing point at every crosscut.

Shuttle Cars

As with mine cars, the bigger the shuttle car, within limits set by seam and other conditions, the fewer the changes and consequently the fewer the interruptions in mining and loading at the face. Also, as with mine cars, the closer the changing point, assuming the usual two and sometimes three cars per unit, the higher the efficiency.

The pressure to increase unit capacity has resulted in the development of 6-wheeled shuttle car articulated in the center to permit the two ends to move up and down and thus minimize the roofing that otherwise would be encountered (*Coal Age*, May, 1958, p 140). A 27-in-high model has a rated capacity of 4½ tons. Driving is done by the two middle wheels.

AC and torque-converter cars not only offer advantages of simplicity and low operating and maintenance costs, but bring wide use of AC much closer. If such cars could be coupled with diesel locomotives on the mainline or, as is now the practice in a number of operations,

with belts, then the change to 100% AC is rendered that much easier.

Future possibilities are full-diesel cars, or cars with batteries and small diesel-generator sets to handle peaks and recharge batteries, which would be much smaller, during low-load or nonoperating periods.

SURGE CARS, PICKUP LOADERS—The relatively low capacity of the early continuous miners quickly brought out the fact that the intermittency of shuttle-car service, even with the best of setups, was a considerable handicap. Among the steps to offset this handicap is the establishment of storage or surge capacity between miner and shuttle car. The mine bottom is one form of storage, in turn bringing in the pickup loader. Even with the cost of the loader and operator, the increase in miner performance has been sufficient in many instances to show a handsome gain.

The surge car is a possibility under some circumstances but is not a cureall. The car may be a standard shuttle car or a specially built unit. Whether to use a surge car can be determined only after a careful study.

HAULAGE LIMITS—The maximum length of shuttle-car haul is approximately 500 ft with two cars per face unit. The tendency, however, is to keep the maximum under 400 ft where possible because of excessive loss of miner or loader working time as room depths near their limit. This may be offset in part by introducing a third car, which, however, requires extra investment in equipment and labor, and very careful organization of the haulage system to prevent interference. However, some operators use the third car quite successfully. One, as an example, operates the third car as a combination unit. In other words, it works part of the time moving coal and part of the time bringing up supplies.

The cable-reel limit can be stretched by anchoring the cable at the midpoint and backlashing on half the run. Some operators who have tried it recommend against the practice not only because the long hauls raise loader waiting time, but because backlash reeling is more difficult and is harder on cable, guides and reel. Therefore usual practice is to anchor at the discharge point. Shock-absorber-type anchorages are great cable savers, incidentally.

Though the ultimate savings at any particular operation depend upon the mining plan and conditions, the possibilities in keeping shuttle-car distances short may be substantial. For example, extra moving of transfer stations to keep distance down by 200 ft per round trip might cost, say, 1½c per ton, while the reduction in face cost as a result of higher machine output might be 10c. Separate travelways, where possible, also contribute to speeding up shuttle-car service and thus increasing face output.

TRANSFER TO MINE CARS—Unless the track is sunk, an elevator or ramp is necessary for transferring from standard shuttle cars to mine cars. Sinking is done at some mines, and normally where this is the practice an effort is made to have one station serve places in both sides of an entry. The same practice also is followed where the top must be shot to permit the use of elevators or ramps. To keep the shuttle-car haul down to the minimum, stations normally are established at intervals of 200 to 300 ft. And also to reduce top-shooting as much as possible, at least one operator has developed a low-type elevating unit mounted on a crawler-type mining machine truck (*Coal Age*, September, 1955, p 72). A high-speed conveyor is provided to eliminate slowing down or stopping shuttle-car discharge. In this instance, transfer stations are prepared by the development crews every 120 ft.

Making it possible for the shuttle car to discharge at maximum rate without stopping is, as noted, a major element in keeping an operation up to maximum efficiency. If elevator capacity is low, a hopper should be provided—usually by sinking the boot into the bottom. Or the chain should be speeded up. Provision also should be made for changing mine cars without stopping the elevator or shuttle car. Making shuttle-car and mine-car capacity match is one method being used at new mines or where cars or shuttle cars are being replaced. This method is especially effective with elevating-discharge cars, but works well with any other type of transfer equipment.

TRANSFER TO BELTS—A number of mines apparently encounter little difficulty in side loading belts from shuttle cars, but a greater number limit belt loading to end-on only, with usually a special hopper or a hopper-tailpiece combination to start the coal on its way. Side loading, these operators contend, results in greater spillage and, because the coal comes on at 90 deg, is harder on belts.

Where side loading is practiced, with the belt in the center of three headings, it is possible, by assigning a crosscut on each side to a shuttle car, to load at four points, provided the crosscuts are offset. Also, with two cars, one may be assigned to the end position and the other to a side position in the next crosscut down to keep them apart at all times. Other systems are of course possible, and include the end- and side-loading types for three cars shown in accompanying illustrations.

In end loading, with auxiliary hoppers, there is an opportunity to install a grizzly to pad the belt with fines before the lumps hit. To load belts, either side or end, a low ramp or an elevating-discharge car is necessary. A saddle-type hopper that can be moved along the conveyor (*Coal Age*, February, 1957, p 108) can help materially when it is necessary to shift side-loading stations often.

Unless belt speed and width are sufficient to move the coal as fast as the shuttle car can discharge, delays are bound to occur. To prevent these, and also to improve belt-loading conditions, a number of steps may be taken. One is to install a two-speed motor with automatic timing control to speed up the belt while the shuttle car is discharging and cut it back automatically afterward. Transfer conveyors or elevators capable of taking maximum shuttle-car discharge and at the same time designed to feed to the belt at the proper rate are used at a number of mines. Conveyors may be of the belt, chain or shaker type, with or without hopper and with or without two-speed controls.

Operating Reports

Designing a Haulage System—How equipment was selected for a slope operation producing 12,000 tpd with eventual hauls of 4 to 15 mi. *Coal Age*, September, 1957, p 84.

Closed-Circuit Television—How one mine uses it for smoother, safer shaft hoisting. *Coal Age*, October, 1957, p 90.

Wreck Prevention—Permanent-type rerailers for various conditions. *Coal Age*, October, 1957, p 96.

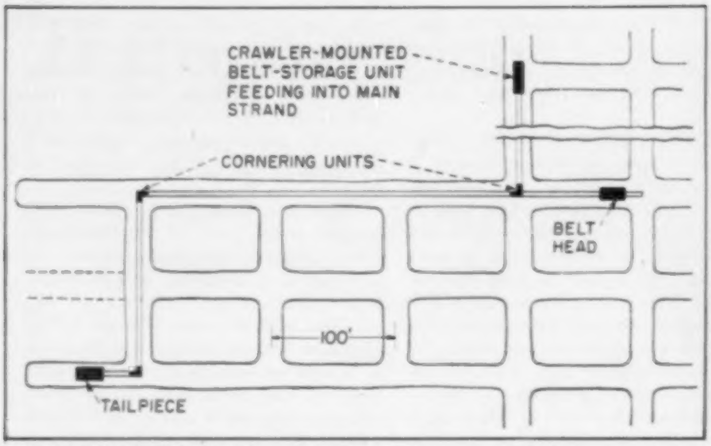
Rope Belts—Report on experience at the mine where the rope belt was pioneered, taking in mainline and panel units. Saving in installation of 4,000-ft mainline unit estimated at $50,000, compared to conventional unit. *Coal Age*, February, 1958, p 124.

Beltman's Guide—How to install and operate belt conveyors; how to troubleshoot conveyor operation and belting difficulties. *Coal Age*, March, 1958, p 122.

unit. Both three-wheeled and four-wheeled trailers with lift endgates are used, and after the tractor pulls the trip to the

With the bridge conveyor followed the extensible unit, a continuous conveying route is provided from the mining unit

2. Gravity Retarding—Feasible with a rope and a brake drum with manually or motor-applied brake.



CORNERING BELT PLAN provides for crawler-mounted belt-storage unit for additional flexibility and fewer stops for extensions. Groups of places may be developed without moving the drive and transfer point.

CORNERING DEVICE permits 90-deg turns in belt conveyor to keep continuous transportation close to face machines.

AUTOMATICITY THE KEYNOTE in haulage as in other operations. Here 25-ton cars are being loaded automatically by a mother belt with the aid of overlapping car ends and switches actuated by rollers and ball-type floats.

Incidentally, where a number of elevators or conveyors discharge to a belt, it is possible to interlock to prevent simultaneous operation and over-loading of the belt by the outby unit. One mine uses a skate wheel on a flat spring under the top run of the belt (*Coal Age*, May, 1951, p 83). When the belt is loaded, the spring is depressed to hold in a button locking out all elevators except the one in use. As soon as the belt clears, the button is released to permit another elevator to start automatically. Other suggestions are finger or paddle switches actuated by being struck by coal to prevent an elevator or a crossbelt from pouring coal onto an already loaded main belt.

SHUTTLE-CAR ROADS—Ruts, dust and mud are the major difficulties in building and maintaining shuttle-car roads. A good rut preventive used at many mines is to sling a section of light rail or angle crosswise underneath the cars and just clearing the bottom, using chain or wire rope.

Where there is much mud, planking is the usual answer, normally with 2x8's or 2x12's on stringers of the same material under the tire tracks. Spaces of, say, 3 in between planks reduce the number necessary and also provide places in which to lay cables serving other machines that might use or cross the roadway.

Battery Tractors

Rubber-tired trailers or trailer trains pulled by battery tractors are among the developments and modifications of the original shuttle-car idea. They were developed primarily to meet the problems of the small drift mines in coal under 36 to 40 in, with some in 24 in or less.

Before the train idea was evolved, a number of designs for a low-cost shuttle car for such operations had been developed (*Coal Age*, April, 1953, p 88; July, 1953, p 88; February, 1954 p 116; June, 1954, p 101). Built with automotive axles and certain other automotive parts, the earliest such units usually had a capacity of less than 1 ton and were designed for hand loading. The usual motive power was a single-phase repulsion-induction motor with automotive-type transmission. The trailing cable, up to 1,000 ft in length, was dragged behind the unit. In later models, capacity was increased to 3 tons to permit use behind loading machines, and DC power was employed. Also, tractors were developed for pulling bottom-dump trailers. In all instances, the units operate all the way from the face to the dump outside.

The battery tractor is used to pull up to 10 trailers (*Coal Age*, May, 1955, p 99). It acts like a gathering locomotive also functioning as a mainline haulage

unit. Both three-wheeled and four-wheeled trailers with lift endgates are used, and after the tractor pulls the trip to the outside it usually backs the cars one by one to a gravity dump, though dumping is done by hand on occasion. Hauls up to ½ mi have been handled by equipment of this type.

Conveyors

BRIDGE CONVEYORS—By providing a continuous and continuously functioning connection between loader and room conveyor, and by relieving the operator of all but the responsibility for keeping the machine in coal, the bridge unit has resulted in major increases in tons per man at the face. A typical bridge plan appears on p 57 of this issue.

Evolution of the bridge unit has included development of the tandem bridge. Full discussion of the use of the tandem bridge in continuous mining under a variety of conditions appears in *Coal Age*, February, 1954, p 92.

ARTICULATED AND CASCADE CONVEYORS—Development of the continuous miner and accompanying emphasis on development of conveying mediums also has resulted in the design of articulated and cascade conveyors and conveyor systems. One version of the articulated conveyor developed for a boring-type miner consists of a series of interconnected belt conveyors on wheels, each with its own driving and propelling motors (*Coal Age*, January, 1954, p 64).

The cascade system is substantially similar, but has some differences. One is in the fact that the conveyors need not be coupled, though hitches are provided to permit the train to be pulled behind the boring unit in one remote mining system.

Extensible Conveyors

Development of the bridge unit was the first step in really bringing the conveyor into the picture as a means of serving loading machines and continuous miners. The next step was to design the room conveyor so that it could be easily extended to keep up with the face unit. The first such unit was the extensible belt, first with standard angle, channel and plate frames. Recently, the rope type has taken over almost completely. Special flexible idlers are key items with both types.

Chain-type conveyors of the extensible type are a recent offering (*Coal Age*, May, 1957, p 111). In this unit, made up of sections mounted on rubber-tired wheels, each section has a gooseneck in the middle, with the raised rear end riding on the low front end of the succeeding section. This results in an extension of approximately 50% of the length of each section.

With the bridge conveyor followed the extensible unit, a continuous conveying route is provided from the mining unit to the transfer point or main line. Advances up to 1,000 ft can be made without moving out of the place and without any other operations than adding stands and belt. Sections of belt and stands 100 ft long, permitting advances of 50 ft, usually are added in less than 5 min. Plans for taking pillars with extensible belts are included with other plans in the sections on "Opening and Development," "Continuous Mining" and "Conveyor and Machine Loading" in this issue.

As an example of results with extensible belts, one mine listed among the savings the elimination of six surge-car and six shuttle-car operators per working day of three shifts.

Adding a 100-ft roll of belt for a 50-ft advance takes two men 3 to 5 min at this operation, while moving the complete unit out of one room and into another takes 60 min.

THE CORNERING BELT—A new coal-company development permitting a belt conveyor to be turned 90 deg without breaking the belt and setting up an auxiliary drive increases the flexibility of the extensible unit and permits development of groups of places without moving the drive and transfer point.

The cornering or right-angle-turn device also makes possible a system of development eliminating a number of the stoppages and time and labor involved in even the relatively few interruptions with the conventional extensible unit. As shown in the accompanying diagram, this is accomplished by means of a crawler-mounted storage section in a heading in advance of the opening in which the main belt section is placed. When the usual length of extension represented in the belt stored on the drums is exhausted, the entire crawler unit is trammed forward or backward as necessary to permit a new advance with no further operation.

Trip Loading

Set up system that will prevent delays to face units. Conduct such loading with no men, if possible, and in any event with no more than one.

Trip Movers

Various systems and units for moving trips past loading stations, whether they be ramps, elevators, belt discharges, or what have you, include the following among others now used:

1. Gravity—Possible but hazardous with the usual spragging.

2. Gravity Retarding—Feasible with a rope and a brake drum with manually or motor-applied brake.

3. Operator-Controlled Locomotive—Fairly widely employed in the past and still employed in a number of mines. Ordinarily means an extra labor cost unless the same motorman pulls to sidetrack or outside in which case care must be taken to see that the trip-changing interval is not too great. Complete looping of track, discussed more fully later in this section, facilitates this trip-moving scheme. And where locomotives pull to the outside and heavy grades are encountered, a few operators put locomotives both in front and behind trips both with loop track and with conventional layouts to achieve uninterrupted haulage.

4. Remotely Controlled Locomotive—Machine with brake set up as required and with the controller on the first point, on separate section of wire which is energized to move locomotive and trip by switch operated by boomman or attendant.

5. Remotely Controlled Trip-Spotting Hoist—Sometimes accompanied by smaller hoist to pull rope back for coupling to fresh trip.

6. Barney, Chain-Feeder and Ram-Type Between-the-Rails Spotters—Newest in the line of trip-moving equipment, these units are positive and accurate in operation and permit designing transfer stations for maximum efficiency in trip changing. The changing function can be preset or controlled by limit switches for precision and also for automatic performance if desired. Also such equipment lends itself to operation by shuttle-car drivers, and thus, even if not made automatic, requires no special attendants.

Track Layouts

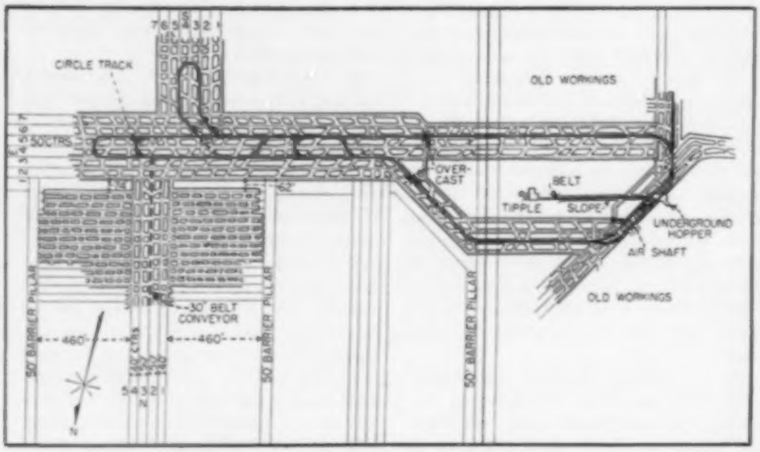
The simplest form of track layout for car or trip loading is the tail-track system. The track can merely be extended down the heading, or it can be turned right or left, as shown in an accompanying plan, or it may be turned right or left and then turned back U-fashion in an adjacent heading. The major disadvantage is that trips must come out the same way they go in, meaning increased loss of time unless the changing track is very close.

Sidetrack or loop-track systems (see accompanying plan and also other plans in "Opening and Development," "Continuous Mining" and "Conveyor and Machine-Loading" sections of this issue) provide access from both ends, and thus permit the quickest-possible trip changes, with no time loss at all if properly set up. The sidetrack—if that is the system—may be in the same heading as the main track. More usually, however, it is in an adjacent heading. Or the sidetrack may, in effect, be made continuous

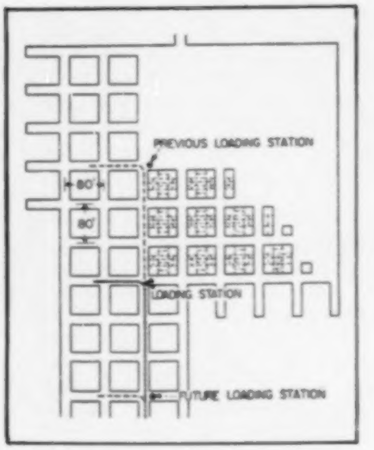
vision for dynamic braking where grades

DRAINAGE—Mud and water can re-

ness, he uses not only the regular tele-



TRIP-LOADING PLAN illustrated above involves circle tracks around the beltheads, permitting locomotives to move trips continuously without storing empties. The loop is completed at the slope bottom.



SIMPLEST TRIP LOADING is tail track, turned 90 deg through crosscut, as shown in this plan.

by tracking the second heading and installing chutes and crossovers at intervals. Double tracking represents some extra expense but does result in greater flexibility and more assurance of quickest-possible trip changes.

Automatic Loading

Complete loading of trips without any operators or attendants whatever already has been achieved in coal mining. Now, the number of such installations is increasing at a fairly rapid pace. Late-type underground stations include facilities for automatically diverting the coal from one car to another, controlling the hoist moving the trip, and starting and stopping the belts. Even cars off the track are provided for.

Switching Coal

The problem of switching coal flow one car to the next in continuous trip loading can be met in a number of ways. One is the overlapping mine car (*Coal Age*, January, 1956, p 70) or articulated trip in which facilities to bridge the gap are built onto the cars. Thus, there is no need to stop either conveyor or elevator, or trip, during loading. Increased interest in this type of car is reflected in a rising trend in installation.

Where the coal flow is not too great, means of preventing spillage during car change include a simple plate or chute to catch coal during the change.

Heavier flows of coal, as off a mother belt, usually require power or some other type of equipment for a quick change. Power equipment includes the short reversible conveyor mounted transversely under the head of the main belt. Equipment without power includes a "pants chute" with flop gate to divert the coal stream from one car to the next.

Main Haulage

Use big cars and high-capacity locomotives for minimum haulage cost.

Provide track that will permit high-speed operation with a minimum of maintenance.

Consider belts for main and secondary haulage, especially the latter.

Whatever its type, the goals in main haulage are (1) ample capacity with operation scheduled to prevent any interruption of loading or mining at the face, and (2) operation with minimum manpower and equipment.

Rail Haulage

ONE-STAGE OR MULTISTAGE?—Main haulage usually is in two stages, relay and main-line, with a few operations dividing it into relay, secondary and main. There is a disposition, however, to question whether multistage operation should be adopted automatically. One-stage operation requires heavy track to the belt head or other loading station, but the extra cost may be much more than offset by decreased haulage labor and maintenance costs.

CARS AND LOCOMOTIVES—Even though cars are less and less taken to the face, where size has an appreciable effect on loading-machine productivity, capacity still is an important factor even in main-line service. One argument for the biggest possible car is that it costs relatively less to buy big cars than small cars. A second is that the big car holds more coal per pound of car weight, and therefore less dead metal has to be dragged around for the same coal.

In the case of locomotives, if one big one can replace two smaller ones, there is an obvious saving in labor. Or two smaller units can be made into a tandem job to get the same saving. In at least one instance also, three small machines were tripled into a single 12-mph unit with spectacular savings.

Other examples of changes to bigger cars and locomotives include replacement of 2¾-ton wood cars with 13-ton steel units and the installation of new high-capacity high-speed locomotives at one property. New dumping facilities and rebuilding of the main haulage road rounded out the program. The two new locomotives replaced five smaller units and motor crews were cut to one man, releasing about 55 men to other jobs and cutting haulage cost about 75%.

Aids to safety, efficient operation and low maintenance in car design include:

1. **Automatic couplers.**
2. **Spring draft and buffing gear.**
3. **Antifriction—bearing wheels.** With high speeds and swivel trucks, as in 8-wheel design, wheel metal and treatment becomes a more critical problem. Answers include special mixtures and chilling with cast iron, and cast or forged steel.
4. **Lightweight corrosion-resisting materials.** Newest is aluminum plate, shapes and extrusions for maximum weight reduction. Another form of construction for simplicity and strength with minimum weight is the use of standard structural shapes—for example, channels for sides and ends on low-vein cars.

Antifriction bearings also mark the modern locomotive, which, especially in main-line service, tends toward a higher rated speed, usually 12 to 15 mph, with certain types rated up to 35 to 40 mph. Modern electrical controls include pro-

vision for dynamic braking where grades warrant. For absolute reliability in such braking, a 32 V battery permits continued operation even when trolley power fails.

Track

Generally accepted standards for good main-line track include 70- to 90-lb rail on heavy treated ties laid in crushed slag, gravel or cinder ballast. The importance of treated ties is shown by one study indicating total tie costs for 1 mi of track for 20 yr as follows: treated ties, $10,600; untreated ties, $34,000.

Welding has come sharply to the fore as a means of joining rails, with steel arc the most widely employed. Curves should have a radius of 300 to 500 ft and should be super-elevated. Turnouts should not be less than Nos. 5 to 8. Trolley wire should be hung at a uniform height above the rail and aligned with it at the proper distance outside. Shoe-type collectors should be used where feasible, especially on heavy-duty locomotives, and the trolley wire should be adequately lubricated at the proper time intervals for low maintenance and efficient current collection.

Throws and switch-position indicators are essential for safe, smooth main-line haulage, while alloy frogs and proper guarding keep down maintenance and reduce derailments. Automatic switch-throwers and remotely actuated derails save labor and promote safety.

DOUBLE TRACK OR SINGLE?—Most authorities agree that double track is for the big mines, though they split on what is "big." Advantages of double tracking include complete separation and no interference between empty and loaded haulage. Also, since waiting at sidetracks and passing tracks is eliminated, fewer cars and locomotives are required. Furthermore, one track usually always is available and therefore production seldom if ever is completely interrupted. In addition, some mining men point out, double tracking where grades are heavy makes it unnecessary to use a tail locomotive, which might otherwise be considered desirable. Also, it permits installing spring-type derails on upgrades.

Almost the equivalent of double tracking can be attained by proper location of properly designed passing tracks.

Use of locomotives on both ends of trips may have an advantage other than safety. At one mine this practice also makes it unnecessary to run locomotives around trips, either at the panels or at the main dump (drop-bottom cars). Sections are equipped with looped loading tracks and hydraulic car spotters. The haulage crews, one for each of the two locomotives, change trips at the loading points.

DRAINAGE—Mud and water can reduce the capacity of a haulage system as much as one-third or more. Proper ditching is a major answer to keeping haulage roads dry. If gravity disposal is impossible, sumps should be constructed to receive the water and facilitate disposal by pumping. The importance certain mines ascribe to dry haulage roads is attested by a program of building cisterns in crosscuts at strategic points and equipping these with automatically controlled pumps discharging to an outside line.

GRADING—Eliminating bumps and hollows not only makes for smoother, safer haulage but also can result in a significant saving in number of locomotives and crews necessary for a given tonnage. If possible, sustained grades against the loads of over 1¼ or 1½% should be avoided. If averages higher than that cannot be avoided, then it is even more essential to knock off peaks.

TRACK CLEANING—Smoother, faster haulage, less track deterioration and greater safety are the major reasons for emphasis on clean track. Track-cleaning machines naturally reduce the cost to a minimum, while cars in good condition reduce spillage and stretch out the intervals between cleaning. In many instances, a considerable tonnage of good coal is reclaimed in the cleaning process, which might well be credited against cleaning cost. Some mines, as a matter of fact, figure they are well ahead of the game by salvaging coal off the track.

LIGHTING—Safety, speed of operation and maintenance all are facilitated by good lighting of haulage roads. The latest types of units are fluorescent tubes, which provide a significant increase in light output for the same current. For a discussion of fluorescent lighting in working sections, and of incandescent lighting along haulage roads, see *Coal Age*, February, 1956, p 84.

Incandescent lamps were the original light source, with the usual spacing as 75 to 100 ft. With the usual wattage of lamps, this normally is sufficient to comply with the rule that there should be no dark spots between lamps. Glare elimination requires proper location, and if necessary, shielding. Mounting lamps along one rib, rather than in the center, may help in glare reduction.

Haulage Control

Except where the haulage system is of the simplest type, the dispatcher is essential not only for efficiency in haulage but also as a means of keeping a finger on conditions and progress throughout the operation for the benefit of the foreman and superintendent. In his business, he uses not only the regular telephone but, along with other mine personnel, the carrier-current phone—on locomotives and cages as well as in offices and stationary communication posts throughout the mine.

Ready communication with locomotive operators is the great advantage of the carrier-current instrument, the use of which some mine managers have stated has raised output and efficiency 10% or more.

Block signals at times can take over in part or completely in control of haulage, aside from their other major function of preventing interference and collisions. Normally, however, in the control area, they supplement and round out the dispatching program, making it, in the experience of many mines, more accurate and efficient.

Belt Haulage

Because of the increased difficulty and cost of setting up and maintaining an efficient track haulage system in thin coal where top or bottom must be taken, the belt conveyor, with a few exceptions, first made its mark in underground transportation in low-vein operations. It was of particular benefit in eliminating brushing and providing continuity of transportation in panel haulage, which normally aggregates several times main-line haulage over the life of the property, and was a natural complement of conveyor transportation in rooms. Since that time the belt also has moved into thick-coal mines for both main-line and panel service.

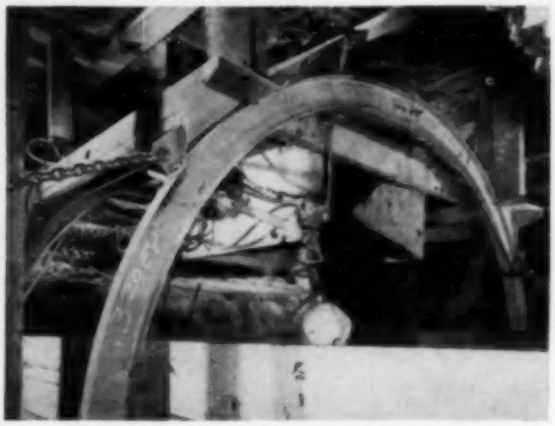
ROPE BELTS—Reducing the weight, bulk and complications of the conveyor structure has of course been the goal of the designer since the first belt conveyor went into service. The need is especially great in the thinner coal where the belt has some added advantages.

Conveyor sections have been progressively lightened and redesigned for quick assembly and disassembly. The use of a wire rope as the carrying member for the top-strand idlers is the latest step toward simplification and reduction of weight and bulk. Among other advantages, there is a major saving in installation time even though the same care is taken—as it should be—with alignment and other installation requirements. Compared to the conveyor structure of 20 yr, which today involves a labor cost of 55½c per foot at one operation, the cost of extending the rope-belt conveyor is only 11c per foot.

Special low-type units have been designed as part of the evolution of the rope belt. Contemplated applications include surface as well as underground

PORTABLE-HEAD CONVEYOR discharges at left into mine cars where automatic loading controls swing flopgate to prevent spillage between cars. Drive is out of of picture at right.

DRIVE UNIT of new belt operates from truck which is anchored in position in tracked crosscut. Unit can be moved in 4 manshifts.



ARCH UNIT, straddling main line track, supports discharge pulley, flopgate chute and other equipment of portable-head conveyer belt for coal-mine application.

and, among other things, the suspension of rope belts over long spans is being studied to add to its versatility.

PORTABLE BELT HEADS—A new development with the rope-belt conveyor is the portable belt head. The first such unit was designed for 2,000-ft-long 36-in mother units specifically designed to receive coal from shuttle cars and discharge into large mine cars. The basic elements are common to most conveyors but the arrangement makes the difference.

The drive section, including motor, controller and power-transmission facilities, is mounted as a complete unit on a rail truck. To move it into position, it is trammed to a spot in the first crosscut inby the main line, which means that the drive is 60 to 100 ft from the belt discharge. The drive stays on the truck, which is anchored in place while remaining on the rail.

The discharge pulley, together with a flopgate chute, are integral parts of a knockdown arch unit which is set up to straddle the mainline track. The arch, flopgate chute and pulley assembly are hauled to the site on a mine car. The arch then is set up and the two-way chute and pulley mounted in place.

Wire ropes are then attached to the arch and are strung out along the entry, passing over the drive. Two or three adjustable supports are used to hold the rope between the discharge and the drive. The remainder of the conveyor is the standard rope-type unit.

One move involved shifting the entire 2,000-ft-long unit from one entry to another and setting it up ready for use. Total labor required was less than 4 manshifts. In contrast, the usual requirements for the conventional rope belt is 30 manshifts or more.

Belt Operation

One secret of efficiency in mainline belt haulage is proper installation according to the recommendations of the conveyor and belt manufacturer. Another is the employment of one man properly trained and equipped to patrol service and lubricate each 1½ to 2 mi of belt line. A third is proper loading of the belt. Chutes should turn the coal in the direction of the belt, lay down a cushion of fines and, if possible, put the coal on the belt at the same speed. In a few high-tonnage systems, short speedup belts are used to turn coal from panel belts and deposit it on the main-line units in the right direction and at the right speed. Thus, the punishment is largely confined to the speedup unit. Big lumps, incidentally, require a wider belt, a heavier carcass and proper covers. Cushion idlers at transfer points are essential in helping protect the belts. Good splicing is a must.

The most effective method of determining motor and/or belt overloading, particularly with panel belts, is reading the motor current with a tongtype or other meter. Stuck idlers, piled up loose coal rubbing on the belt, and belt rubbing against the frame are common causes of motor overloading. Another, in addition to piling on too much coal, is too much belt for the grades.

FIRE PROTECTION—In addition to the already-accepted methods (*Coal Age*, March, 1958, p 122) the first line of defense against belt fires today is use of fire-resistant cover and impregnating materials. Those employed in belts approved by the USBM are two:

1. Neoprene.
2. Polyvinyl chloride (PVC).

Neoprene already has found substantial use and PVC is coming into the picture, particularly in the form of the "plyless" belt. In other words, a single woven carcass of the desired thickness is employed. It is impregnated with the plastic and the covers applied in the same operation. Covers are the same thickness on both sides and either may be used as the carrying side. One of the first users reports not only practically complete resistance to ignition but also high resistance to cutting, gouging, edge wear, tearing out of splices and other mechanical damage.

An additional advantage of the fire-resistant belt is elimination of the need for a neutral-air opening or a separate split, thus approximately halving the number of stoppings required in a beltway.

ELECTRICAL PROTECTION — Suggestions for electrical control and protection include:

1. Connecting each drive to the line through a stepped resistance.
2. Sequence starting, outby drive first, with proper time delay for each subsequent drive.
3. Automatic stopping of all inby conveyors or elevators if any belt should stop for any reason. The usual device is a centrifugal switch.
4. Interlocking conveyors or elevators feeding to a belt to prevent feeding onto one already full loaded. Devices include finger- or paddle-actuated switches, as well as the skatewheel spring contactmaker described elsewhere in this section.
5. Providing overload or pileup protection at belt transfers, using paddles or other devices to actuate switches and shut down the inby drive. These switches should be of the momentary-contact-type so that the inby conveyor will start again when the overload is cleared.
6. Providing a means of stopping the conveyor anywhere along its length to permit the beltman or any man riding to stop the belt at any time. Continuous pullcord-type controls fastened to the roof also provide protection against falls.
7. Providing drive-pully slippage control to stop the unit as soon as slippage occurs. A centrifugal switch with pulley riding on the belt, or a centrifugal switch driven by a chain from the bend or snub pulley are two possible devices. A third is a differential control with two pulleys, one riding the belt and the other the drive pulley so that when one gets out of step the drive is stopped.

BELT CLEANING—A number of devices, each more or less satisfactory, have been developed for cleaning belts before they go onto the return idlers. A recent one apparently coming closest to the ideal is a length of piano wire mounted under the head pulley and almost touching the belt (*Coal Age*, November, 1952, p 89).

DETECTING BELT TEARS—One of the few practicable methods of detecting major tears in operating belts has been developed at a middle western mine (*Coal Age*, January, 1956, p 88). It consists of a horizontal rod 2 in in front of the head pulley. When struck by a torn flap thrown out from the belt by centrifugal force, the rod is knocked down to open an electrical switch and stop the belt until it receives attention.

Hoisting

Use slope belts where possible and consider special high-strength conveyor belts for long-length slopes and high lifts to cut down number of drives and transfers.

Make shaft hoisting and auxiliary operations as nearly automatic as possible.

In the absence of special circumstances, the belt slope is the usual coal hoisting facility installed today. Low operating labor and low maintenance are the major reasons, while improvements in belt design, including rayon, nylon and steel-cord tension elements, have made it possible to install single belt runs up to 3,000 ft or more in hoisting, thus raising the vertical lift to more than 800 ft.

Belts also work equally well in lowering coal where the terrain permits their installation at inclinations of under approximately 20 deg. Other facilities for lowering include monitors and rope-and-button conveyors and so on.

FEEDING TO BELTS—Any of the standard types of dumps may be employed in transferring coal from mine cars to the belt, unless bottom-dump cars are employed. If so a necessary intermediary is a hopper or bin. Where belts are used for main-line haulage, boomed shuttle belts are used to lay the coal down in a longer and therefore larger-capacity bin. Short transfer and speedup belts also are used between hoppers and slope belts to take the shock and protect the slope unit from some of the wear and tear. Magnetic tramp-iron-detection equipment on either the speedup or main slope belt stops the equipment and permits removal of metal that might result in damage.

Shaft Hoisting

The skip hoist usually raises the equivalent of 2 or 3 cars each trip and thus normally can operate more slowly, with lower acceleration peaks. Where self-dumping cages are employed, fabricating them of high-strength alloys or aluminum reduces dead weight and consequently improves the hoisting operation.

As with all other mining operations, economy in hoisting is a matter of equipment and controls to conserve manpower. Now, any type of vertical hoist—skip, self-dumping or overturning cage, and platform—can be made completely automatic, including caging and, with platform equipment, decaging. Even if complete automatic operation is not desired, automatic cagers, tripmakers and the like speed up the hoisting process and save labor.

Handling Men

Keep travel distance short by building new man-and-materials portals at the necessary intervals.

Use transportation equipment and methods that provide the maximum in safety with the maximum in time-saving.

In these piping portal-to-portal days, a major consideration in designing facilities for handling men is keeping travel time to a minimum. As an example, if actual working time is 6¼ hr, or 375 min, increasing it 15 min is equivalent to producing the same tonnage with 1/25th fewer men. Greater time savings enhance the benefits and increase the limit of expenditures to secure them. At an average of 6 mph for a man trip, if permitted by law or regulations, cutting the distance 2 mi saves 40 min per man in production time.

Portal relocation, among other things, provides an opportunity for streamlining the handling of men and also attaining maximum convenience and comfort in changing in and out. A collateral benefit is an up-to-date field supply setup, with possibly also a field maintenance shop that is much nearer the active workings.

KEY OBJECTIVES—Aside from sup-

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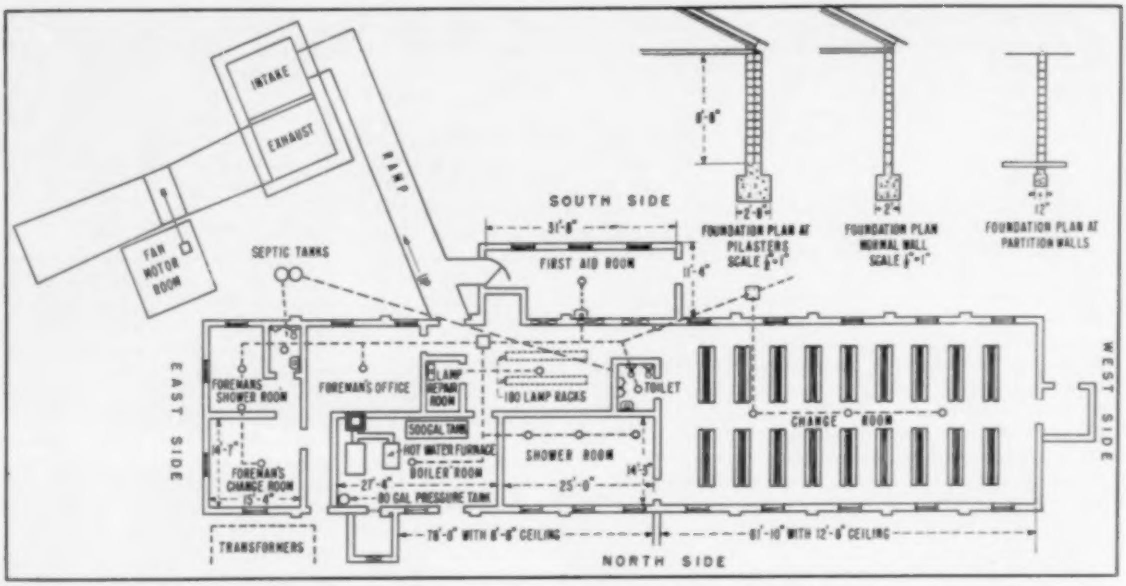


NEW PORTAL BUILDING cutting 54 min off travel time provides for comfort and convenience of employees and supervisors. Ample parking space and a service station are provided near the building.

plies and maintenance, key objectives in portal design include:

Ample all-weather parking.

Good wash and change facilities.

Good lamphandling facilities.

Protected facilities for men waiting to board trips—from weather and electricity particularly.

Adequate first-aid facilities.

As an example of the possibilities of portal relocation, one mine, for an investment of $450,000 in a shaft and portal building, cut 54 min off the travel time and raised output per man-day 1.8 tons (*Coal Age*, December, 1956, p 66).

Hoisting

Where men are handled through separate man-and-material shafts, either at the main opening or back at field portals, usual practice today is to install pushbutton-operated elevator-type equipment in capacities up to 50 men, which reduces the total time required to put a crew into the mine car or bring it out. The cage may also be adapted to handling heavy supply items, though the tendency is to use the regular opening for this purpose, especially drift or slope.

Drilled shafts with automatic hoists may provide a lower-cost answer to the problem of putting portals close to the working areas. At one mine (*Coal Age*, November, 1955, p 60) a 72-in drilled shaft was fitted with a double-deck circular cage with a capacity of 10 men per deck. Pushbuttons control the automatic hoist. Hoisting distance is 487 ft. Travel time was cut 45 min with a resultant rise in output.

SLOPE CARS—Where men enter through slopes, some mines, where the regular equipment cannot be employed, provide special slope cars for that part of the trip. If single cars are employed, the trend today is to equip them with magnetic track brakes actuated by an overspeed device or by a pushbutton under the control of a foreman or triprider. Where several cars are put together in a trip, they can be preceded by a pilot car with magnetic-brake equipment. If men walk the slope, a "ski-tow" installation, which gives them a one-handed pull, is a major help in negotiating the stairs in the "up" direction.

Car Transportation

Where height is sufficient, the covered mantrip car is practically standard for transporting men by rail. In addition to cars pulled by locomotives self-powered units are available in capacities up to full section crews, making it unnecessary to detach locomotives for this service. Where several individual cars are in service, dispatching and block signals are essential to prevent collisions. At trackless mines, corresponding equipment on rubber, battery powered, is available.

Low coal makes it more difficult to cover cars that go into areas where top is not taken. Flat-bed rail cars with rubber mats can be used, with the men lying crossways. Self-propelled types include one in which the men lie down with knees up to each end (*Coal Age*, March, 1954, p 190). Capacity is sufficient for a section crew of 11 men. Height over the rails is 24 in. As in thick coal, equivalent equipment is available on rubber for thin-coal operations.

In addition to regular mantrip cars, a variety of rail and rubber-mounted cars may be employed to save time and promote efficiency in transporting mechanics, electricians and repairmen, as well as officials. The list includes even small one-man three-wheeled "trikes" for trackless operations. Types for mechanics, electricians and repairmen include tool and supply boxes and wells or decks for carrying heavy items.

Belt Transportation

Under proper safeguards, movement of men on belts has proved both safe and efficient. The major safeguards include ample vertical clearance all the way, extra clearance at points where men get on and especially where they get off, equipment to reduce speed to approximately 200 to 250 fpm, and an emergency stop cord or stop system all along the belt so that any man can stop it at any time. The system should be designed so that the belt cannot be restarted without a check to see that no hazard is involved. A space of at least 6 ft must be maintained between each man on a belt.

Belts may be reversed to take men in, and a few mines have designed mainline systems with that in view. In going in, men necessarily must get off and change if more than one belt is in service. There also should be a rigid rule that men get off and change coming out as well. Ample clearance and smooth unencumbered footing should be provided at all loading and unloading points. Finally, in addition to all other steps, no movement of men on belts should be permitted except while a responsible supervisor is present.

EFFICIENT, MODERN FANS create the pressure differential which causes a current of air to flow. The sum and substance of practical ventilation is to take maximum advantage of this differential to achieve maximum economy.

Ventilation

A MINE FAN is somewhat akin to an electric generator. Both create a difference in pressure at a definite point in a circuit, the generator creating a difference in electrical pressure and the fan a difference in fluid pressure. In both cases the pressure differential causes a current to flow, and the practical techniques of either electric-power distribution or mine ventilation consist of taking maximum advantage of this pressure difference and the resulting flow with full regard for safety, efficiency and economy.

How to attain this maximum advantage is the substance of the ventilation engineer's daily work—and an appreciable portion of the job of every legally certified mine official. The ventilation task boils down to this:

The pressure differential must be of such magnitude that the desired quantity of air will flow against the resistance offered by the airways. This resistance must be kept to a practical minimum to minimize, in turn, the power required to create the pressure difference. The air current will have to be split to provide safer ventilation in various areas of the mine, and splitting introduces a need for regulation to insure balance.

Coursing the air within the splits requires strict supervision and iron-clad discipline, especially in continuous-mining sections. Furthermore, a management decision will have to be made as to whether worked-out areas are to be sealed or ventilated. A decision to ventilate these areas means that a system of bleeder openings must be designed. Then the entire circuit must be patrolled and maintained because a coal-mine ventilation system grows longer and more complex every working day.

Basic Principles

Keeping velocity within reasonable limits is vital in conserving power and preventing dust dispersal.

First order of business in modernizing an existing layout should be the completion of an accurate velocity-pressure survey.

Most of the effort is put forth with one eye on the power bill, since the goal is to provide adequate ventilation at minimum power. And following back from the power bill, it is seen that keeping the velocity of the air within reasonable limits is a basic requirement because (1) power varies as the cube of the velocity; (2) pressure varies as the square of the velocity, and (3) quantity varies directly with velocity.

A change in any of these conditions naturally forces a change in all others since all are interdependent. Furthermore, existing conditions at a particular mine, lumped together in the term equivalent orifice, finally determine the magnitude of the ventilating job.

Improvements in varying degree may be achieved by cleaning up airways to reduce resistance, sealing leakage, splitting and regulating in the most efficient manner, shortening the distance of air travel through the use of new airshafts and other such steps.

Even at mines where the ventilating duty is governed by the amount of methane made in the workings and the necessity of diluting it and sweeping it away, there is the possibility of draining off some of the methane through boreholes tapping the solid coal ahead of the mining.

SURVEYS—These fundamentals apply in planning ventilation for a new mine or in revamping or maintaining the system at an existing property. Taking the latter case, because high-cost ventilation is more of a problem at mines already opened up and more or less advanced in years, any effort to improve, modify or update a ventilating system must be based upon accurate pressure and velocity surveys. Regions of high resistance or excessive velocity must be identified, and the extent of wasteful leakage must be determined.

Ventilating Equipment

Total ventilating efficiency is a combination of fan efficiency and mine characteristics.

Practice Trends

METHANE DETECTION—Automatic systems for continuous methane detection are undergoing extensive tests. These units include provisions for interrupting electric power to face machines when methane content exceeds a predetermined limit.

AUXILIARY FACE VENTILATION—A number of schemes employing auxiliary fans are being tested in a search for better, safer ways to ventilate immediate face areas in continuous mining.

IMPROVED COURSING—In multiple-entry systems in gassy mines air is brought up center headings, split both ways at faces and returned through outer headings.

Operating Reports

Ventilation survey serves as the basis for revamping to achieve lower costs and higher ventilating efficiency. *Coal Age*, June, 1956, p 68.

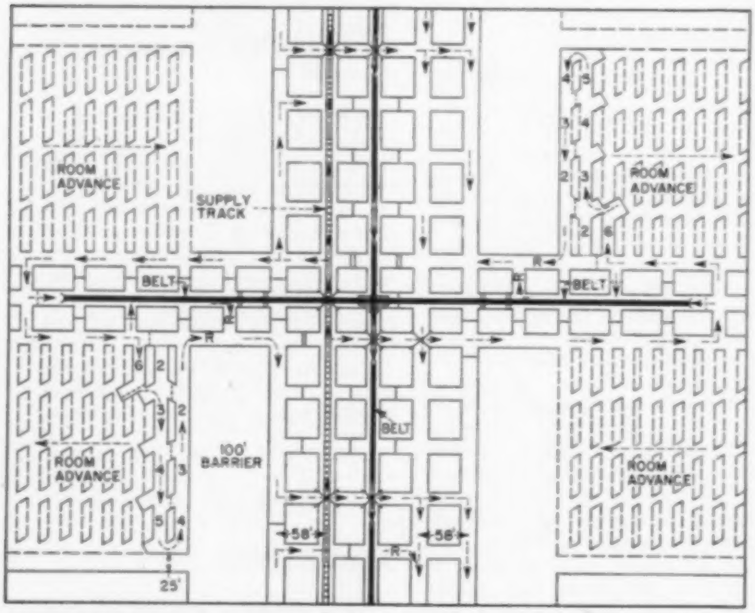
Five bleeder-entry plans and their effectiveness, as analyzed by the Bureau of Mines. *Coal Age*, December, 1956, p 70.

Core drilling of large boreholes is most economical way of sinking ventilating shafts in Pocahontas No. 4 seam. *Coal Age*, June, 1957, p 99.

Passage of fronts in the weather system may affect methane emission and mine-moisture conditions. *Coal Age*, February, 1958, p 164.

Auxiliary fans mounted on continuous miners can improve face ventilation. *Coal Age*, March, 1958, p 106.

Blasthole shaft-sinking shows significant cost and safety advantages. *Coal Age*, June, 1958, p 106.



EACH WORKING SECTION and the belt heading in this layout for continuous mining is ventilated by a separate split of air.

Proper use of auxiliary air-control equipment can reduce costs and extend useful life of main fans and air openings.

Modern fans, with few alterations in mine conditions, often can effect substantial reductions in power consumption, partly because of the inherently higher efficiency of the new units and partly because the new fans can be more closely matched to mine characteristics. Quick blade adjustment makes it relatively easy to keep mine and fan more closely paired.

Better design in ventilating materials is not confined to fans alone. Also available are improved curtain materials, including treated cloth and neoprene-coated types. The latest item in this line is a plastic check curtain with a transparent center panel to aid shuttle-car operators.

REUSABLE MATERIALS—New materials for stoppings include telescoping metal sections and sheet plywood. Noteworthy features in these are rapid installation for savings in labor and full reclamation for savings in supply costs. Not to be overlooked are cinder blocks, also reusable in many instances, and sprayable coatings for sealing against leakage.

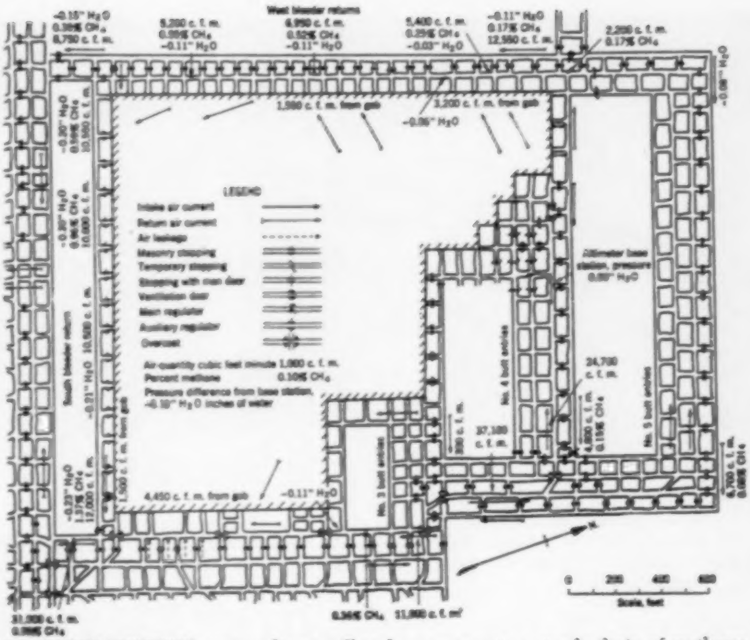
Prefabricated materials, corrugated pipe sections for example, may be used to construct air bridges, thus cutting the cost of such construction and permitting the use of more overcasts to the exclusion of doors and other wasteful air-current controls. As a result of these developments, overcast is no longer a bad word in ventilation.

AUXILIARIES—Auxiliary air movers, including fans and portable evase units for the control of compressed air, may be of some help when properly used with the approval of regulatory agencies. Better ventilation in continuous-mining has been achieved through the use of auxiliary exhaust fans and flexible tubing. Installed with safeguards against recirculation, the fan provides adequate air at a velocity which is sufficient to remove dusts to an appreciable degree, improve visibility at the face and dissipate the heat generated by the face equipment. Improvement of these fans is a matter now receiving intensive study in the industry.

A brand new starter that bears study in continuous mining applications is a wet-type inertial dust collector in a small package that holds promise of moving air over these machines and efficiently collecting dust in one operation. A description of the unit appears in the Equipment News department of *Coal Age*, July, 1957.

In anthracite, trumpet-shaped air movers, connected to compressed-air lines, have been used to direct air to the faces of steeply-pitching places beyond the last open cross-heading.

Doors are a necessity at some point in every system. Recent developments in these include a new compressed-air-powered automatic door for heavily-traveled haulageways. The operating controls are actuated through the trolley system and all mechanical linkage and the operating cylinder are suspended from the mine roof and attached to the top of the door. None of the parts is exposed to wet bottom conditions nor to damage from possible derailments. Some mines now swing their conventional doors from steel jacks to make possible faster relocations.



BLEEDER ENTRIES surrounding a pillared area promote a steady drain of methane from the gob, thereby inhibiting any sudden outburst.

Controlling Costs

Good planning can reduce the cost of power, the most expensive item in total ventilating costs.

Choose one of several new drilling techniques to provide low-cost auxiliary ventilation openings.

The advantages to be found in modern ventilating equipment may be fully realized or they may remain undeveloped, depending upon the degree of care and skill employed in conducting the air through the workings. Excessive leakage and insufficient airway area are especially wasteful, no matter how efficient the fan.

Fugitive air is the most expensive luxury in today's coal mines—and the most dispensable. Surveys of some mines show that up to 80% of the air moving through the fan never reaches the working faces. It leaks through poor stoppings, around doors and so on, back into the returns without moving anywhere near the active sections. Even in mines where ventilation is given more serious consideration leakage may short-circuit up to 30% and more of the incoming air supply.

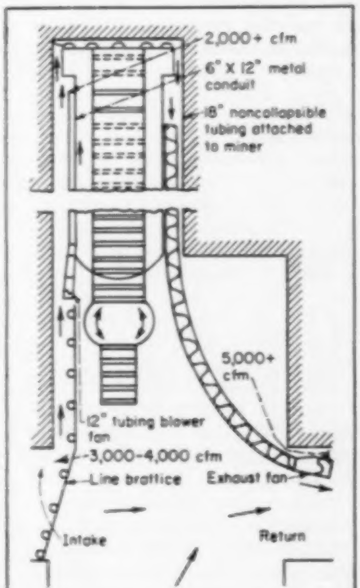
PREVENT LEAKAGE—The penalties in fugitive air, measured in terms of wasted power, are shocking in some instances. Since a certain quantity at the face is mandatory, fan speed must be increased to insure that effective face ventilation, over and above leakage, will meet these legal requirements. And power consumption increases as the cube, while the increased velocity contributes to still more leakage.

Sealing at points of excessive leakage is one way to lick the problem. Another and better way is to look for ways to achieve one-way flow, thus eliminating leakage opportunities by doing away with side-by-side intakes and returns separated by porous stoppings and other leaky control devices. Airshafts or openings to the outcrop may be used as new fan locations or additional intake openings to get the one-way flow. Even in deep cover, the cost of a new shaft may be more than recovered in a reasonable time in power savings alone.

Furthermore, the cost of sinking a shaft is not what it used to be. In one instance (*Coal Age*, June, 1958, p 106), a shaft was sunk by drilling a circle of large-diameter holes with an overburden drill, then shooting the hard core against the relief provided by the drillholes. The job was quickly done with fewer men and in greater safety.

In another instance (*Coal Age*, November, 1955, p 60), a shaft was sunk using a core drill which cuts a 75-in hole at rates of 4 ft per hr in limestone and 1 ft per hr in sandstone.

In another area where numerous wants and faults occur, it is found that a pressure system is best in ventilating long narrow gassy areas of coal so long as bleeder shafts are provided at the extremities of these coal areas. As soon as the limits of these areas are determined by completion of development work, a bleeder shaft is drilled down to the coal to remove the gas-laden air from the pillaring sections. Loose ground through which the bleeder shaft is to be drilled is consolidated by grouting. Then a 36- to 48-in hole is Calyx-drilled to make the bleeder shaft. The cost of drilling such a 36-in hole was $99.95 per ft, and a 48-in hole, $127.00 per ft.



FACE VENTILATION with blow and exhaust fans aids continuous mining.

One-way travel contributes to even bigger power savings inasmuch as a change to this system results in increased airway area with former returns now serving as intakes. The upshot is either

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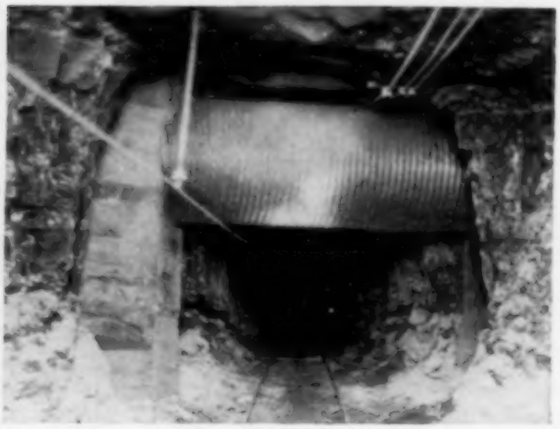


MONEY-SAVING SUPPLIES include plastic check curtain with transparent center panel (left) and corrugated pipe for overcasts. Both may be reclaimed and used again and both contribute to increased safety.

reduced velocity for the same quantity or higher quantity at the same velocity, a bonus either way.

Coursing the Air

Other things being equal, it may be possible to plan production activities to provide ventilation with minimum regulation.

Increased safety is by all odds the big reason for splitting air currents underground. An explosion in a mine ventilated by one continuous current of air could affect the entire mine, while in a mine served by several splits the effects would be more confined.

There are other good reasons for splitting. The mine resistance is reduced, power is conserved, and better local control of the air becomes possible.

The ideal situation, which shows all splits naturally balanced in resistance, is seldom achieved in actual practice, since in some splits development work will predominate and, in others, room work. Some regulation becomes necessary to raise the resistance of all other splits to that of the longest or high-resistance split. Up to a point regulation is helpful, but it can become wasteful.

It pays to investigate the possibility of using an auxiliary fan to serve the high-resistance split alone, thus eliminating any need for adding resistance in the other splits. The benefits are reduced power requirements and lower pressure differentials on stoppings outby the booster fan.

Sometimes a well-planned cleanup in the free split may result in the passage of more air, also reducing the need for added regulation in all other splits. Some companies have found a ventilation bonanza by rehabilitating old airways with roofbolt support in place of timbers. The resulting increased area and decreased resistance work together in compounding the benefits.

FACE VENTILATION — Recent studies indicate that getting a sufficient volume of air up to the face crosscut is not the big problem. In continuous mining the big problem is to conduct this available air across the "teeth" of the machine, right at the immediate face. Even a well-constructed line curtain may leak most of the intake air before it comes anywhere near the face. If line curtains are used, their installation must be closely supervised in every instance.

Bureau of Mines engineers now are actively testing and searching for safe and sane applications of auxiliary fans, either set in the mine openings or mounted directly on the mining machine. One possibility is a combination of blowing and exhaust fans, as explained in the March, 1958 issue of *Coal Age*, p 106.

Other studies now actively pursued by the Bureau of Mines and equipment manufacturers point toward the development of a methane detector that will interrupt line power to electrified face machines when methane content rises to a predetermined value. The Bureau recently published a list of features these devices should have to satisfy the needs.

Ventilating for Safety

Use check curtains to keep air moving along pillar lines, through the gob and into bleeder openings.

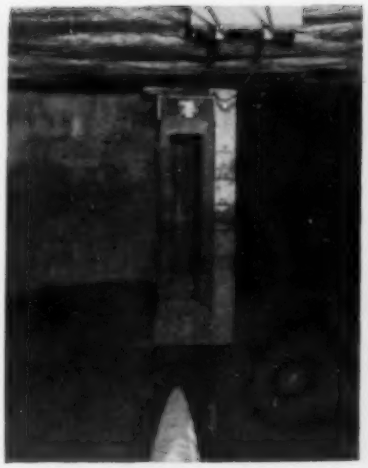
Decisions to seal or ventilate gob areas must be based on thorough study of local conditions, but recent development plans show bleeder systems becoming more popular.

Accumulations of gas in worked-out areas are especially hazardous in today's coal mines because of the rapid extraction in highly mechanized methods and the consequent increase in the rate of methane emission. The worked-out area increases rapidly, close by the active places where a number of electric-powered machines are concentrated and the entire crew is assembled.

In conditions like these, more and more operators are including bleeders in their mine projections to ring gob areas with openings through which air passing through the gob may be conducted directly to the returns. In some instances, air from the worked-out areas passes into the returns through regulators which control the quantity of air passing through the gob as well as insuring adequate air and positive pressure along the pillar line. Properly maintained bleeder headings practically eliminate the possibility of gas migration during periods of low atmospheric pressure.

Along similar lines, it is advantageous in gassy conditions to begin recovery of room panels by driving a pair of line rooms along the outby limit of the panels parallel to the mains. Such rooms serve as an extra pair of low-cost airways, and the outby room may be preserved in the bleeder network after the panel has been robbed.

Specialized designs for ventilation may become necessary when a change to continuous mining is in the works; particularly if methane is a problem. At one mine (*Coal Age*, February, 1956, p 88), the problem was handled by designing a bleeder-entry system to serve pillar areas and by setting up effective line-curtain techniques for use at active faces.



MINIMUM ATTENDANCE requirements is the big advantage in providing automatic controls at the pump (left) and at the sump (right). Priming-water supply also is automatically controlled, and only periodic maintenance checks are needed.

Pumping and Drainage

WATER will be present at most mines in quantities that will make it necessary to lay detailed plans for handling it. In brief, the best way to proceed is to keep out of the workings as much water as possible, using the methods described later in this article, then to design pumping and piping systems for removing the water that cannot be kept out by economical diversion methods.

Diversion ditches around openings, sealed stream beds at troublesome points, grouting underground to seal off stream channels, new channels if necessary and well-constructed dams are possible controls which may be used to keep water out of underground workings. Flumes make it possible to conduct surface water across pervious areas of mining properties and dump it back into natural drainage channels on the other side.

Practice Trends

COMMUNITY PUMPING STATIONS, supported by more than one company, eliminate rehandling of the same water at one mine after another.

IMPROVED METHODS and equipment for surface or underground drilling lead to wider use of borehole-and-pump combinations for more economical mine drainage.

AUTOMATIC CONTROL of pumps reduces need for attendants, thus reducing service-labor costs.

QUICK-CONNECTING aluminum tubing as a pipeline material contributes to major savings in installation time.

Gravity Drainage

Planning openings for gravity drainage also can result in gradients in favor of loads in track haulage.

Look for opportunities to create outcrop openings or to drill drainage boreholes to lower worked-out areas.

It is neither possible nor practicable in most instances to keep out all water. Some provisions must be made for handling underground inflow.

Other things being equal, it may be possible to lay out the mine so that workings advance to the rise, giving an assist to haulage as well as to drainage.

USING BOREHOLES—In other instances, it may be possible to drill boreholes to the cropline or into a sump area to permit gravity flow by the most direct path. At one mine, where some places necessarily are advanced to the dip, 2-in boreholes are drilled at the face through 60 ft bottom rock to old work-

DUAL-PURPOSE BOREHOLE contains power cables and a 4-in drainage line to provide these services by the most direct route.

ings in the seam below. The old workings are open to the outcrop, facilitating gravity drainage of both seams.

SUMPS IN DIP WORKINGS—At a new mine, where the seam dips 8%, room panels are worked to the dip from strike entries on advance and up the pitch on retreat. The idea is that the dip workings are finished before extensive areas have been opened up, and the dip rooms will serve as sumps for the uphill workings.

When all's said and done, however, chances are some pumping will have to be done. But handling water with today's equipment is a far cry from the difficult job it was in the past. Today's advantages include efficient pumps for any type of duty, electric power in place of steam, automatic controls to cut the cost of operation and materials designed for long life at reasonable cost.

Pump Selection

Use single-stage pumps in series if solids are present to an appreciable extent in the water to be handled.

Select pump materials on the basis of a complete water analysis.

The type of pump selected depends entirely upon the pumping job to be done. In two out of three of today's mine-drainage applications, centrifugals of one type or another will be found, but each of these is practically a tailor-made unit.

PUMP SPECIFICATIONS—The pumping job at one mine may be entirely different from that of its nearest neighboring mine with regard to such factors as volume, total head and water acidity. The best bet, therefore, is to work closely with a pump manufacturer in determining the one best pump for the application.

The final selection will depend upon whether the service is to be continuous or intermittent, whether AC or DC power is to be used, how much water is to be handled, how much variation may be expected in suction and discharge heads and so on.

SPECIAL SYSTEMS—If the water is free of solids, a multistage centrifugal unit to work against a high head may be used, but if solids are present a number of single-stage units in series should be used because solids ruin multistage pumps. Thus pump selection becomes an exercise in balancing a number of sometimes-conflicting factors. Complete foreknowledge of the conditions under which the pump is to work is vital to successful selection.

Also important in selection is a decision as to whether the total pumping capacity should be provided in a single unit or in twins, with the latter choice getting the nod in most recent installations because of the resulting flexibility.

Foresight should be used in arranging the pumping schedule to dovetail with operations. For example, at a three-shift mine it may be desirable to provide "peakless" pumping to spread the pumping load over the entire day, while at a two-shift mine it might be better to provide enough capacity to handle all the water on the off shift when demands for production power are at a minimum. In either case, sump capacity will have to be planned and provided to suit the system finally selected.

And in certain special cases, it would be well to investigate the possibility of "community" systems among several mines or companies. These would eliminate the waste of rehandling the same water at one property after another.

Planning Water Lines

Eliminate fittings and sharp bends wherever possible to keep line friction to a minimum.

Don't overlook the need for lining or sealing underground ditches in multiple-seam mines to keep water from leaking to lower workings.

The best pump in the world can be limited by a poorly-designed piping system. What are some of the factors to be considered in system design?

Usually the major variable which is amenable to some measure of control is the friction head in the piping itself. The quantity to be pumped is a definite figure and the static head is fairly fixed, but the friction head can be held to a minimum by designing for the largest-diameter straightest pipe-line it is possible to achieve.

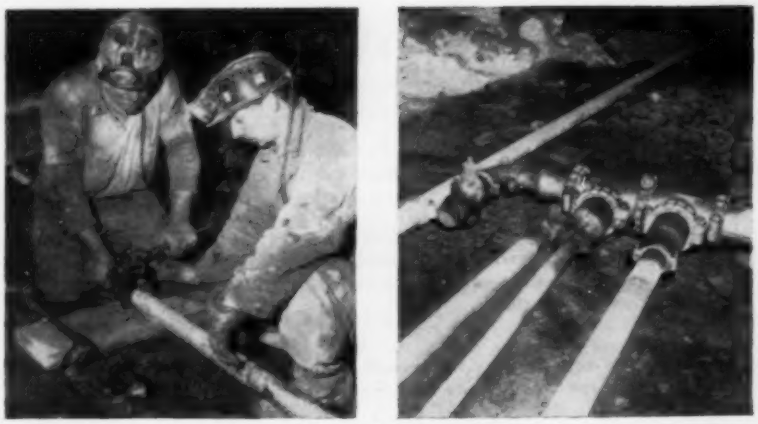
Operating Reports

Aluminum tubing—Weight- and labor-savings features. *Coal Age*, April, 1958, p 110.

Water Neutralization—Automatic lime feeder neutralizes water in strip-pit sump before discharge to settling pond prior to drainage to streams. *Coal Age*, February, 1957, p 101.

Acid Control—New approach involves getting water out of the mine immediately through boreholes to reduce sulfur pickup. *Coal Age*, March, 1957, p 68.

Dual-Purpose Borehole—4-in pump line installed in same hole with four 2-in pipes for power cables. *Coal Age*, June, 1957, p 70.



GROOVING TOOLS, quick connectors and aluminum pipe effect substantial savings in pipeline installation labor.

MINIMUM FITTINGS – Small pipe and numerous fittings and turns will extract a penalty in the form of either higher power requirements or reduced volume of discharge.

In the normal case, pipe of the largest usable diameter will be most economical in the long run.

SYSTEM DESIGN—A well-designed pump installation will show these features:

- The suction line leads straight into the pump for a length equal to four to six pipe diameters.
- The suction pipe is one or two sizes larger than the pump nozzle, and it is connected to the pump through an accentric reducer which is properly placed to eliminate suction-line air pockets.
- The drive motor and pump are in good alignment.
- The piping is supported so that the pump carries none of the pipe-line weight.
- Priming auxiliaries, if they are needed, and lubricating facilities are in good working order.

Priming water for one new underground pumping station is taken from the dust-allaying spray water system. An automatic cut-off is provided to disconnect the spray system as soon as the pump takes up its load.

Drainage Systems

Use gravity flow and pumps alternately to minimize power consumption for drainage.

Improved drilling techniques increase the advantages of pumping through boreholes.

Fitting the pumping system into the overall mining plan is another matter. This is another instance where each setup is somewhat different from any other, as local conditions dictate. An example of how to get the most out of a dollar of drainage cost is demonstrated at one mine where three gravity-fed sumps and three pumping stations remove 3,000 gpm in three stages over a distance of 3½ mi. Each station is provided with independent pumping power through a borehole cable. Wood pipe in 8-, 10-, 12- and 16-in diameters is used.

The two main pumps at this property operate on alternate 12-hr cycles thus making a peakless pumping load on the power system. The sumps act as accumulators in making this duty possible.

DEWATERING—At an anthracite mine the problem was to unwater some workings on the other side of a 200-ft barrier pillar to permit recovery of the pillars in the flooded mine. Broken strata above the workings ruled out the possibility of using a borehole to the surface. The solution was to drill a pair of 12-in horizontal holes from the active mine through the barrier pillar to tap the flooded workings. The borehole lines were connected to a 7,000-gpm 700-hp pump which discharged through 2,300 ft of 18-in asbestos-cement pipe installed in the slope of the active mine.

LARGE-DIAMETER BOREHOLES—At another anthracite property, it proved to be more advantageous to drill two 24-in boreholes from the surface to a depth of 537 ft to reach the best natural sump in a worked-out lower vein. Upper veins then could be drained into this sump through smaller boreholes which were drilled at intervals as the workings advanced to keep the pipelines to gathering pumps as short as possible. The two larger boreholes each serve a 4,400-gpm 10-stage pump, driven by a 700-hp 4,000-v AC motor.

Incidentally, both of these anthracite drilling operations were let out on contract to a company that specializes in these projects.

Cutting Drainage Costs

Automatic controls at pumping stations reduce the need for attendance, when properly inspected and maintained.

Lightweight materials and fast couplings result in lower labor costs for pipeline installation.

MINIMUM LABOR—The system must now be operated and maintained with minimum expenditure of service labor. This means that pumps and other drainage equipment must give longer trouble-free service, pipelines must last longer, relocations of pumps and piping must be made in less time, and long runs of piping must be installed in the shortest possible time.

MODERN MATERIALS—Every manufacturer of drainage supplies designs his equipment to perform one or more of these functions. Here are some examples.

Saving Labor in Pumping—Pump controls ranging from simple float switches to elaborate fully-automatic systems for large stations are available. Modern pumps can be made of special alloys or lined with coatings which increase pump life in handling corrosive waters. One anthracite operator found he could increase the interval between overhauls by painting pump interiors with special insulating varnish.

Longer Pipe Life—Asbestos-cement, plastics, aluminum alloys, synthetic rubber, special coatings—all these materials in the form of mine pipe have materially increased time-in-service for pipelines.

Faster Relocation—Fast snap action couplings for use with plain-end pipe now permit fast disassembly and reassembly in a new location of pipelines up to 6 in in diameter. Grooving machines now are available for modifying plain-end pipe to take the faster self-aligning couplings.

Quick Installation of Longer Runs—Long coils of lightweight plastic pipe or long sections of aluminum pipe now can be installed by one or two men, where the same men formerly would be hard-pressed to lay a fraction of this length in the same time.

of a stream of water reflects a combina-

Electric Power

ELECTRIC POWER SYSTEMS, whether AC or DC, should be planned to give maximum service. This is essential in modern-day mining because the size of equipment has increased and will continue to increase as higher productivity per unit is required to maintain coal's position in today's markets.

As a result of this increased equipment capacity, mining operations advance more rapidly than before, and thus create problems in moving conversion equipment or AC load centers more frequently to maintain rated voltage at the face. This has placed more emphasis on good distribution systems than ever before.

Essential items necessary to maintain good electrical service are good power factor of the AC system, transformers of the proper rating, sufficient copper to transmit voltage reasonable distances and, where DC is used, the necessary converting equipment to produce the required kilowatt capacity. The distribution system also should provide adequate protection for equipment and personnel.

AC Theory

Make sure of a working knowledge of AC theory. It is a must in planning an efficient distribution system insuring maximum service and protection of equipment and personnel.

What is AC and how does it differ from DC? Webster defines AC as "a periodic electric conduction current which reverses its direction at regularly recurring intervals. As used in electrical engineering practice, its frequency is determined by the frequency of the alternator supplying it and its successive half waves are similar in shape and area. The standard commercial frequencies are 25 and 60 cycles per second." This means that with AC the current flowing in electrical conductors alternates between positive and negative at a rate of 25 or 60 cycles per second. One complete cycle (360 deg) consists of a half positive and half negative wave, each similar in shape and size. In comparison, DC flows in one direction, always with positive polarity.

Inductance and Capacitance

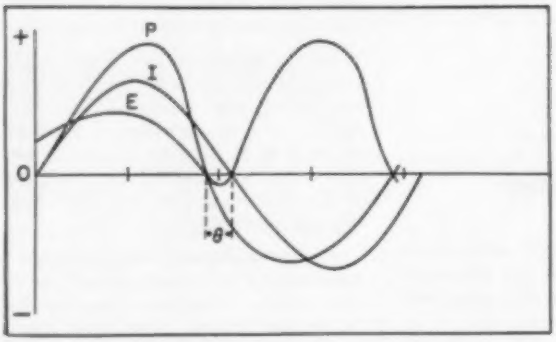
When current flows in conductors, a voltage also is impressed across the conductors. It can be represented by a wave similar to the current wave. The voltage wave reverses its direction ahead of or behind the current wave, depending on the amount of inductance and capacitance in the circuit. The degrees of difference between the two waves at zero is called the phase angle and is the number of degrees by which current lags or leads voltage. The accompanying sketch shows the current lagging. This angle of lag or lead is also related to power factor. The cosine of this angle, termed Cos θ, is the power factor.

When current lags the voltage, the power factor is said to be lagging and the circuit is predominantly inductive. Inductance is opposition to the flow of AC and is present in AC circuits and conductors but not DC. It is produced by a magnetic field which induces a voltage in such a direction as to oppose the change causing it.

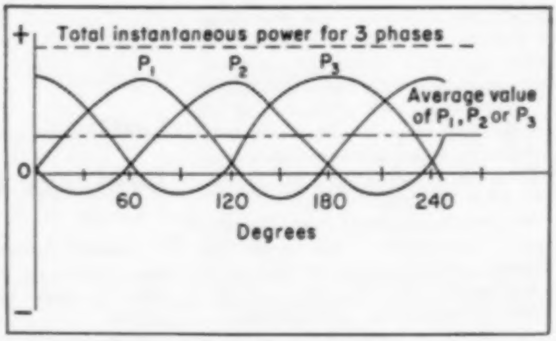
A circuit has a leading power factor when the current leads the voltage. It then is predominantly capacitive. Capacitance oppose changes in voltage and is produced by an electric field set up around the circuit or conductor when current is present. When voltage increases in a circuit energy is transferred from the circuit to the electric field and when it decreases, energy is transferred from the electric field to the circuit. This indicates that energy is stored in the electric field and, when the voltage in the circuit decreases, this stored energy tends to give the line voltage a boost, attempting to maintain a constant voltage.

Power from AC

The product of current and voltage produces still another wave form called power and is analagous to power produced in a hydraulic system. The force



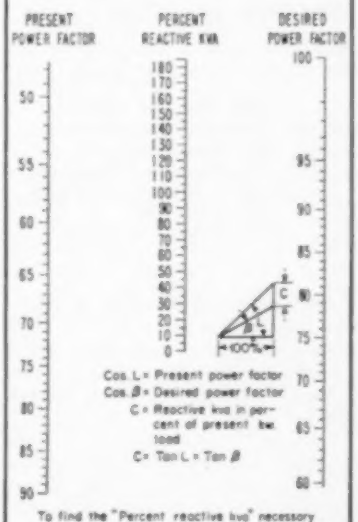
CURRENT (I), VOLTAGE (E), POWER (P), AND POWER FACTOR (θ) in an AC system normally take a wave form.



TOTAL INSTANTANEOUS POWER of three-phase and single-phase AC systems is indicated by the dash lines.

of a stream of water reflects a combination of pressure in pounds per square inch and volume in gallons per minute. In an electrical circuit voltage is the pressure and current is the fluid. Although voltage and current are negative during half their cycle, the power wave is almost always positive. It reverses direction at the phase angle between voltage and current and assumes a negative polarity for a short time only. This, and the fact that power transfer is not constant in magnitude, i.e., pulsates with time, are undesirable features in AC. However, these disadvantages are small compared to DC, mainly because AC permits the use of transformers.

Power in an AC circuit depends on the voltage between conductors, the current flowing in the conductors and the power factor. The higher the voltage the lower the current and the lower the current the smaller the wires which can be used to transmit it. Transformers enable power to be stepped up or down as the case may be. When power is to be transmitted over long distances it is better to use a higher voltage, thus reducing line drop and wire size. At the end of the transmission line it can be stepped down to the desired voltage level.



To find the "Percent reactive kva" necessary to raise the power factor from "Present power factor" to "Desired power factor" lay a straight edge across the chart connecting these two values. Read the "Reactive kva" in percent of the present kilowatt load on the middle scale

BEST METHOD OF CORRECTING POWER FACTOR in a given case can be determined by a careful study of surrounding conditions. Without taking into consideration special features, the amount of corrective KVA may be determined by the use of the above nomograph copyrighted by Westinghouse Electric Corp.

Practice Trends

AC EXPECTED to grow rapidly in the next few years because (1) AC motors, controls and substations cost less, (2) AC equipment maintenance is simpler and (3) AC is more versatile.

THE AVAILABILITY of torque-converter and straight AC shuttle-cars, which eliminate DC at the face, is expected to be a deciding factor as to the type of power that will be employed in new installations.

TRANSMISSION VOLTAGES are being increased. The trend is toward 4,160 V, although a few mines are using 7,200.

Future Possibilities

AS CONCENTRATION, loads and transmission distances increase, 13,000 V may be expected to enter the picture at some future date.

IF DIESEL-POWERED LOCOMOTIVES are permitted in the mines in the future it will be possible to eliminate DC entirely. This would tend to step up the conversion rate.

Operating Reports

Frame Grounding—Problems, solutions and how to devise better equipment grounding methods. *Coal Age*, February, 1955, p 84.

Load Calculations for Power Systems—Methods used to calculate load division of DC mine feeder circuits. *Coal Age*, August, 1955, p 88.

Cutting Power Bills—What the controlling factors are; how to apply them. *Coal Age*, October, 1955, p 76.

Continuous Mining With AC Power—Application of AC power underground and how it is used to reduce electrical maintenance of equipment. *Coal Age*, February, 1956, p 88.

Dual Purpose Borehole—Four 2-in pipes carry power underground in borehole also equipped with 4-in pump line. *Coal Age*, June, 1957, p 70.

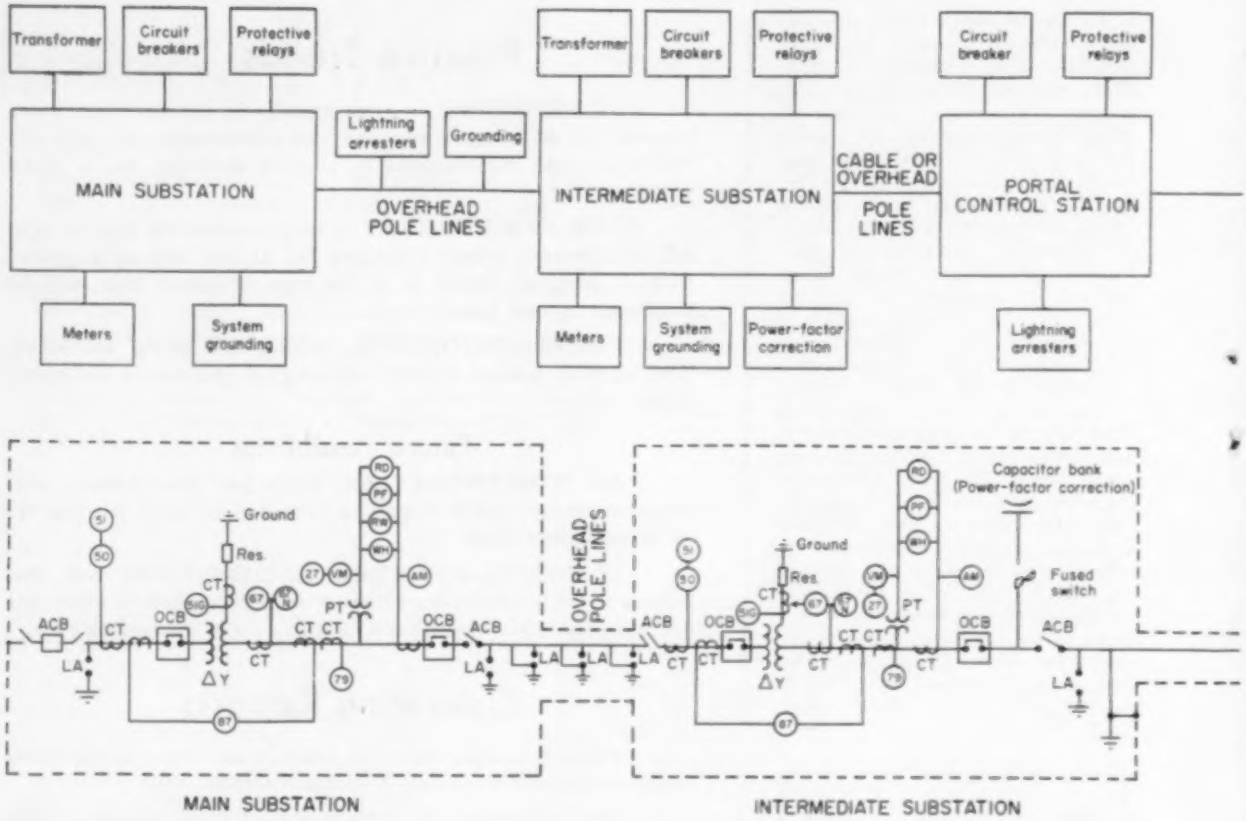
Primary Power Distribution—How 12,000 V AC is distributed to load centers. *Coal Age*, October, 1957, p 79.

Current-Carrying Capacity of Portable Power Cable on Reels—Maximum current capacity and other factors affecting cable life, and suggestions for rating cables on reels. *Coal Age*, January, 1958, p 98.

Distribution of AC Power—How initial design, quality construction and system improvements provide mining operations with an efficient power system. *Coal Age*, March, 1958, p 116.

Mutual inductance is the phenomenon on which both transformers and AC motors operate. A characteristic of the AC circuit is the fact that it produces a flux—the equivalent of current in a magnetic circuit—which links it with another circuit near it. As the current in the first circuit changes (alternates) it causes a change in the mutual flux which in turn induces a voltage in the second circuit. Induction does not take place in a DC circuit because the current does not change. Therefore, it is not possible to use transformers in DC circuits.

It was noted previously that the instantaneous power wave is negative for a short time. In other words, as the wave travels from positive to negative and back to positive, it becomes zero for an instant. Bear in mind that this is an instantaneous wave and that there are 60 of these waves (cycles) per second which produces an average positive wave over a period of time.



THE AC SYSTEM—Upper diagram shows the major divisions, including intermediate substation used in some systems and omitted in others depending upon the need. Lower diagram shows the AC-system components, per list below.

ACB—Air circuit breaker
LA—Lightning arrester
CT—Current transformer
PT—Potential transformer
OCB—Oil circuit breaker
Res—Resistance
51G—Time - delay overcurrent ground relay in neutral circuit
87—Differential relay
67—Directional overcurrent relay (phase)
67N—Directional overcurrent relay (ground)
50—Instantaneous overcurrent relay (phase)
51—Time-delay overcurrent relay (phase)
79—AC reclosing relay
27—Undervoltage relay
VM—Voltmeter
AM—Ammeter
WH—Watthour meter
RW—Recording wattmeter
PF—Power-factor meter
RD—Recording demand meter
85—Pilot wire receiving relay
74—Alarm relay
64—Ground relay

This pulsating or alternating action of the power wave does, however, affect the performance of single-phase motors. On the other hand, three-phase motors do not have this pulsating action.

The difference between the two can best be understood when it is realized that three single-phase power waves are impressed upon the stator of a three-phase motor at the same time, while the single-phase motor has only one wave impressed upon its stator. The combined average instantaneous power wave of the three phases results in a constant wave, thus eliminating the pulsation present in each line of the system. This is the main reason why three-phase motors are more widely used.

From purchased power to actual utilization voltage, AC power offers many advantages. However, AC has more elements of regulation than DC. These elements include power-factor, line reactance and high motor starting currents. The elements of concern in DC are resistance and low motor starting currents.

Power Factor

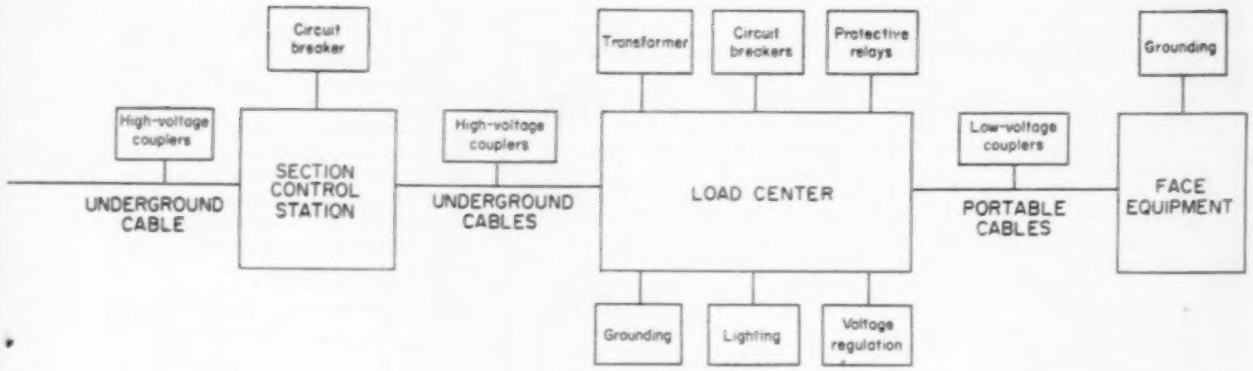
The power factor of a circuit, as noted previously, is the cosine of the angle of lag or lead of the current with respect to voltage. If an AC circuit contained only resistance there would be no problems with power factor because, in a pure resistive circuit, the current and voltage are always in phase. But, in AC there are two other elements to contend with. These are inductance and capacitance, as explained previously, and they are the reason why voltage and current are never in phase in an AC circuit. These elements do not contribute anything to the average or active power, or the power that performs useful work in an AC system. As the current and voltage increase and decrease, energy is transferred between the magnetic and electric fields and the circuit. The effect of this transferring of energy is a false load that burdens the system as much as an actual load. This energy is called reactive or wattless power. It is measured in reactive volt-amperes and is abbreviated *var* or *kvar*.

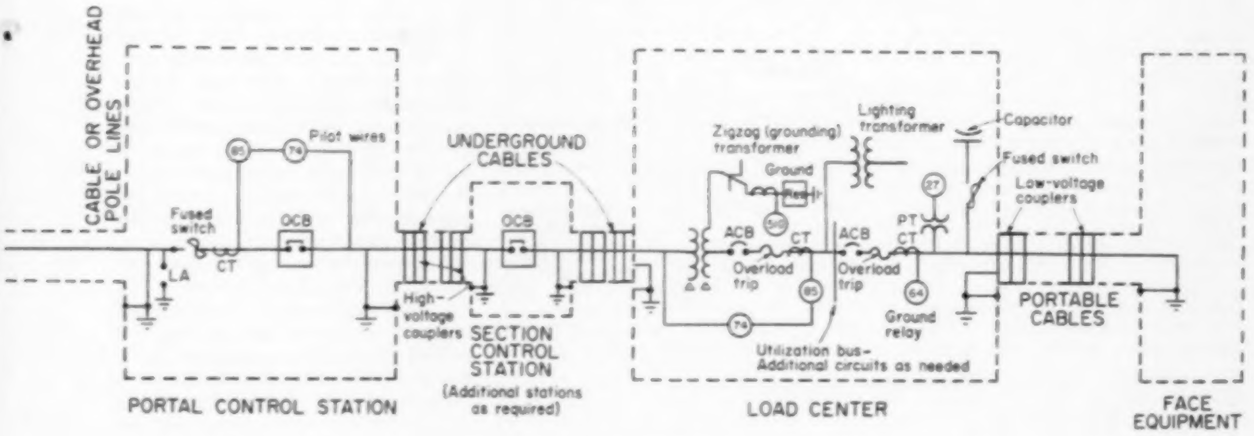
Thus, an AC circuit contains two types of power: first, one that performs work (active or average power) and, second, one that does not (reactive or wattless power).

When a circuit has a poor power factor it is usually a result of inductive loads in the system. Since inductance causes a lagging power factor and a capacitance a leading power factor, it follows that the addition of capacitors to a circuit would tend to reduce the lag. This would tend to improve the power factor by causing it to approach 1 or 100%, which is unity power factor. However, it is not economically possible to have a unity power factor. A 0.95 or 95% power factor is considered good.

BOREHOLE

construction work are being carried on.





Line Reactance

Two types of reactance exist in AC transmissions lines and again these are inductive and capacitive. They affect the transmission of power just as in other circuit equipment. Basically, reactance is the sum of the inductance and capacitance in a circuit. The amount of reactance in transmission lines depends, in part, on the spacing and size of the conductors.

High Starting Currents

Current required to start an AC motor depends on the characteristics of its load and the starting method employed. Generally, a motor requires several times its normal current during the starting period. The rotor resistance also determines the amount of current that a motor will consume to produce a needed torque. High rotor resistance produces high torque and low rotor resistance produces a low torque. The load that the motor will be required to handle will determine the rotor resistance. Higher resistance causes power factor and efficiency to decrease accordingly.

In AC motors, low voltage affects the torque as the square of the voltage but speed is maintained. On the other hand, DC motors tend to lose speed but maintain torque when voltage drops.

Pull-out or maximum torque of an AC motor is attained when the load applied to the rotor causes the rotor to slow down and fall back in space-phase far enough to lag the rotating stator field by 90 deg. When this angle is exceeded the motor stalls. The pull-out torque limitation of AC motors is one reason why such motors are not used on haulage locomotives. In many instances it would be impossible to get a trip started because the torque would be so great that the motor would probably stall each time the load was applied.

AC Service

Plan to distribute power in one or two steps, whichever is more economical. Take into account maximum transmission distances and power demands before selecting the primary and secondary voltages.

Select cables and transformers of the proper rating to receive full benefit of AC service.

An all-AC mine power system starts with a main substation where power is purchased at a high voltage, usually 13,000. The main substation may reduce the voltage to the final levels of 220 or 440, or it may drop it only to 7,200 to 4,160 or 2,400 for transmission to load centers for final reduction. The number of voltage steps and the choice of voltages depends upon system load, transmission distance, safety and limitations imposed by mine laws. The usual practice is to omit the intermediate station. However, it is included in this report on AC to bring in all major variations in an AC system.

With the inclusion of the intermediate substation, the main divisions in an AC system are shown in the block diagram on the previous two pages of this report, while the one-line diagram shows the individual components making up each division. These diagrams employ the standard symbols and numbers adopted by the American Standards Association. These are used to promote familiarity with the electrical symbols used in circuit diagramming.

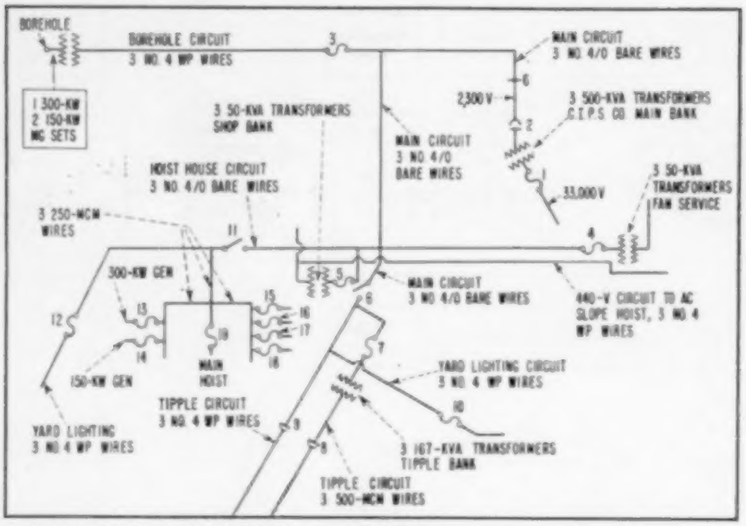
The Main Substation

Although main substations usually are owned by the power company, various switching and protective devices normally are coal-company property. The selection and arrangement of this equipment determines how well the complete

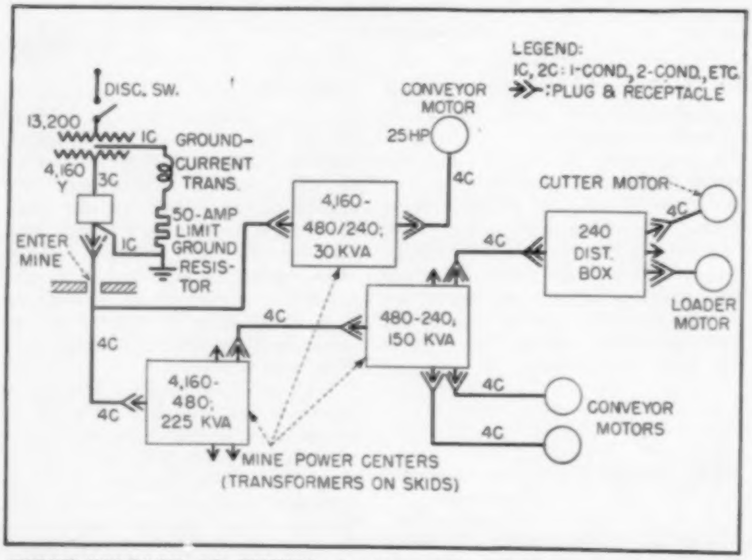
Oil Circuit Breakers

secondary windings. The primary receives current at the input voltage and

The most used and best way of grounding distribution systems is the



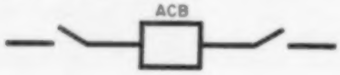
PROTECTIVE EQUIPMENT IN AC SYSTEM for new mine is shown by numbers: (1) primary fused cutouts; (2) secondary breaker; (3) 100-amp fused cutout with 80-amp links; (4) 50-amp fused cutout, 30-amp links, fan circuit; (5) 50-amp fused cutout, 50-amp links, shop transformers; (6) pole-top switch, 3-pole gang-operated, 7.5-kv, 400-amp, tipple circuits; (7) 200 amp 7.5-kv trip-out fused cutout, 125-amp links, tipple transformer bank; (8) 600-amp OCB, tipple circuits; (9) 400-amp OCB, tipple circuit; 50-amp fused cutout, 2-amp links, yard lights; (10) disconnect switch, 7.5-kv, 400-amp, hoist-house circuit; (11) 50-amp fused cutouts, 2-amp links, yard lights; (12-13) 200-amp fused cutouts, 5,000-V 200-amp links, 300-kw m-g set; (14) 200 amp fused cutouts, 5,000-V 150-amp fuse links, 150-kw m-g set; (15-18) 50-amp fused cutouts, 50-amp links, compressors; (19) 200-amp fused cutouts.



THREE-VOLTAGE AC SYSTEM, showing outside substation, ground protection and mining equipment served with values for the various components.

system performs under normal and abnormal conditions. The best normally is as shown in the diagram for the main substation on this page. What the units do is detailed in the following:

Air Circuit Breakers



Circuit breakers or disconnect switches are one of the protective devices used in electrical circuits. They are knife-blade-type disconnecting switches which provide a means of isolating transformers and associated equipment from the source of power. These switches are not installed in the line to interrupt load but are used as a visible means of isolating the equipment when repairs or construction work are being carried on. This type of switch provides a large air space between live wires and equipment which prevents leakage of power to the equipment. It also permits a visible check by workmen that the system is disconnected from the power source. These switches are usually mounted on overhead pole lines and are opened and closed manually by insulated pole hooks that engage holes in each blade.

Lightning Arresters

Protection against overvoltage caused by lightning is accomplished by installing lightning arresters in the system. They are used to reduce power interruption and prevent equipment damage. How much protection against lightning a system should have depends on the location of the system and whether or not the location is subject to frequent lightning strokes. Installation costs vs. equipment value and lost time due to interruptions must also be considered.

Lightning strokes result in an overvoltage in the conductors. Arresters limit the accompanying surge by providing a path for it to travel between line and ground without permitting normal current flow. After a surge of lightning has been directed to ground, the arrester must prevent current in the system from flowing to ground. Summing up, arresters perform two operations: (1) direct the surge to ground and (2) stop the current in the system from flowing to ground after the surge has passed.

Several types of arresters are available for various applications:

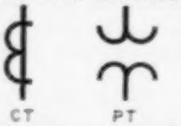
1. Distribution-type.
2. Line-type.
3. Station-type.

Distribution-type arresters are used to protect transformers, cables, capacitors, meters and circuit breakers. They are designed to permit mounting on poles and crossarms. They are relatively inexpensive and are easy to install.

Line-type arresters are similar to the distribution type but are more suited for protecting small equipment.

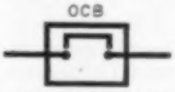
Station-type arresters provide better protection than the other two. They are used, as the name implies, to protect stations and other equipment of extreme importance.

Current Transformers



The next symbol in the one-line diagram represents a current transformer. A discussion on this component along with potential transformers, will appear later in the section on relays since their function is concerned with the application of relays.

Oil Circuit Breakers



On high-voltage systems the oil type circuit breaker is used to guard against overloads or short circuits, and also to permit sectionalizing the system to isolate trouble. It should be noted, however, that air circuit breakers are being used more and more on high voltage systems. The amount of protection that an oil circuit breaker provides depends primarily on the relays associated with it. These will be discussed later.

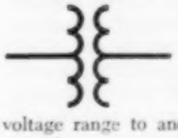
Circuit breakers are normally designed for momentary and interrupting rating, and with automatic interrupting features. Momentary rating is the amount of current that a breaker will withstand, including short circuits from all sources. The breaker should safely open on any current within its rating.

The interrupting rating is the ability of a breaker to interrupt a fault current between the maximum and minimum designed voltage rating of the breaker. The rating is measured in megavolt-amperes, abbreviated *mva* or *arc kva*. The *mva* value is determined by multiplying the kilovolt rating of the breaker by the kiloamperes of the fault current to be interrupted. The *arc kva* value is found by multiplying the kilovolt rating and the amperes.

Interrupting fault currents automatically is achieved by built-in tripping devices or by relays connected to the breaker. There is a wide variety of relays to choose from and the selection depends on the amount of protection required.

Facilities at the main substation normally consist of a master oil circuit breaker (one that provides protection for the overall system) and several branch circuit breakers that feed various loads. The master breaker provides additional back-up protection in case a branch circuit breaker fails to operate when a fault occurs in any one branch. The purpose of branch circuit breakers is to isolate trouble in a particular branch without interrupting service to the other branches.

Transformers



The primary function of a transformer is to change electrical power from one voltage range to another. This makes it possible to transmit, distribute and utilize AC power at the most economical and effective voltages. Unlike AC, DC power must be transmitted from converter, generators or rectifiers to working areas at essentially the same voltage. This imposes a limit on the amount and distances DC can be transmitted.

Transformers contain primary and secondary windings. The primary receives current at the input voltage and the secondary sends it out at the output voltage. The ratio of primary to secondary voltage is the same as the ratio of turns in the primary and secondary windings.

Practically all transformers are single-phase or combined three-phase units, the latter combining all phases in a single case or tank. A three-phase distribution system may employ a single three-phase transformer or three single-phase transformers. The selection is usually a matter of preference. Single-phase units are in the majority but three-phase transformers are gaining in popularity.

In an AC system, the extent of transformation depends on the size of the system (load demand), distance voltage is to be transmitted and voltage limits imposed upon the system by mine laws. Distribution voltages for mining normally range from 13,000 to 220 with transformation taking place as lower voltages are required.

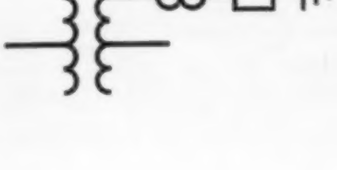
Transformer connections in distribution system are normally delta-Y or delta-delta. These symbols or names have been applied to the different connections because the actual connections resemble these symbols. The delta-Y connection is used on higher voltages and delta-delta on lower voltages. However, this is not a final rule.

Most transformers are equipped with tap changers to change the ratio of the winding. The primary purpose of taps is to increase or decrease the voltage level of the system. Tap-changing does not affect the voltage drop or improve voltage regulation.

Transformers are rated in terms of kilovolt-amperes (*kva*). The prefix *k*, or *kilo*, is equal to 1,000 and is used primarily to reduce volt-ampere values to more convenient number; for example, a 150-kva transformer is the same as a 150,000-va unit.

Since the voltages of transformers are fixed, the rating of an individual unit is determined by the amount of current flowing through it. Care must be exercised in selecting the correct rating to insure efficiency and adequate power for the system and loads, but capacity should not exceed the horsepower rating of the system by any great degree because it results in an increase in wattless current and the imposition of a greater false load on the system.

System Grounding



The most used and best way of grounding distribution systems is the neutral ground method. Since it provides better protection and is simpler, the following discussion will be limited to this system.

Neutral grounding connections can be obtained in two ways:

1. Connect transformers delta-Y.
2. Use zigzag grounding transformers when delta-delta connections are used.

The chief advantages of the delta-Y connection are that it provides a neutral connecting point for grounding purposes, and is the simplest and best way of stabilizing the Y secondary neutral. This method does not require extra equipment to establish a neutral.

If the system is connected delta-delta, there is no neutral connection point available. However, a neutral can be established by installing zigzag grounding transformers. They consist of a three-phase winding with no secondary. Each phase of this transformer is connected to a different line of the system. The grounding transformer neutral is then the same as in the Y-connected system.

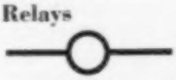
When a neutral has been established for the system, there also must be a method of grounding the neutral. The most desirable practices in mining are: (1) resistance grounding and (2) solid grounding. Resistance grounding is more widely used, especially underground.

In resistance grounding the neutral is connected to ground through one or more resistances regardless of whether the neutral is connected delta-Y or delta-delta with a grounding transformer. The main reason for using resistors in the grounded-neutral system is to limit the amount of current during faults. The advantages are as follows:

1. Minimize electric shock hazards to personnel.
2. Reduce burning effects in faulted electric equipment.
3. Reduce mechanical stresses in circuits and equipment.

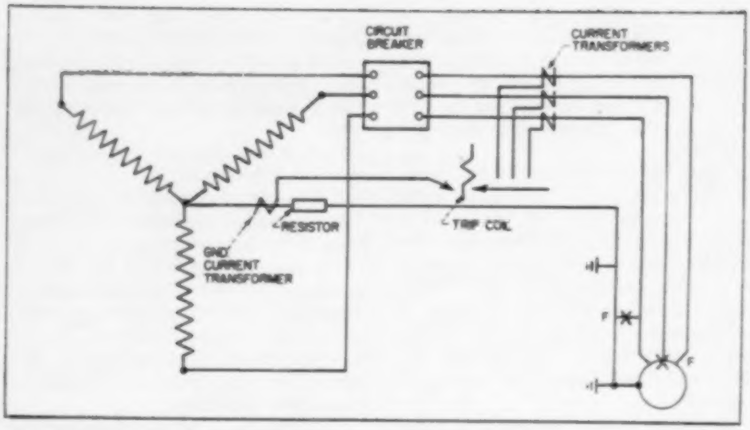
Solidly grounded neutrals are connected directly to ground without any provisions for limiting current. The disadvantage of this method is that personnel are exposed to large ground currents when faults occur.

Relays



Relays detect trouble in a distribution system. They are used in conjunction with circuit breakers to control the operation of breakers when faults occur.

(Current and Potential Transformers – Relays are connected into the system through



AC CIRCUIT PROTECTION by grounding transformer circuit to neutral of Y-connected transformer secondary.

current or potential transformers, often called instrument transformers. Their purpose is to insulate the relays from line voltage and to reduce line current and voltage to values that can be applied to the sensitive mechanisms that are common in relay design. Current transformers are connected in series with the transmission lines. Potential transformers are connected across the lines. These transformers operate on a fixed ratio, for example, a current transformer having a 600- to 5-amp ratio will deliver 5 amp to the relay when a current of 600 amp flows in the line.)

Relays are classified with respect to the rate of speed at which they operate. Basically, these classifications are: (1) instantaneous, (2) high-speed, (3) time-delay and (4) combinations of the three.

Instantaneous relays, as their name implies, operate within a few cycles after faults are detected. High-speed relays differ from instantaneous in that they operate within three cycles or less.

Time-delay relays are those that do not operate until a predetermined time has elapsed. The time ratings are usually adjustable but there are a few that have the time rating built into them.

Distribution systems can be protected from almost any fault condition that might develop within a system by proper selection and coordination of relays. The various relays are named with reference to the protection they provide. Those most often used are: (1) differential, (2) overcurrent or undercurrent and overcurrent directional, (3) overvoltage or undervoltage, (4) phase balance and (5) reclosure. All are available in various time ratings. There are of course other relays but space does not permit complete coverage.

87

Differential Relays—These relays operate on current induction and are used to protect AC equipment from internal faults in individual equipment or faults in sections of distribution systems, including transformers, various rotating units and transmission lines. When used on transformers, they operate on a fixed percentage of unbalance (approximately a 50% ratio) between the primary and secondary windings. The principle of the differential relay is that what enters must leave, except that with transformers the ratio will be different, but this difference is compensated for by using current transformer with corresponding ratios. These relays monitor the current of an electrical system or equipment. When the rated percentage of unbalance is reached the relay operates a breaker and interrupts service until the fault is corrected.

50 51 51G

Overcurrent Relays—These relays are used to trip circuit breakers when abnormal currents of two to three times the normal flow in the circuit. They are adaptable to transmission lines, buses, feeder circuits, transformers and motors.

67 67N

Directional Overcurrent Relays — These differ from straight overcurrent relays in that they are primarily used for ground protection. They are designed to measure fault current in one or two directions. Whether faults will cause flow in one or two directions is determined by system conditions. The two-directional relay is used on transmission lines where ground-fault currents flow in either direction. These relays provide directional as well as overcurrent protection. Other directional relays provide phase protection.

59

Overvoltage Relays — These serve primarily the same purpose as overcurrent relays except that they are connected in the line by potential transformers which measure the voltage across the lines. When an overvoltage exists the relay operates and opens the circuit breaker. Overvoltage relays are not too frequently used in main substations but are included in the list because they can be employed.

27

Undervoltage Relays—Like undercurrent relays, undervoltage relays indicate when voltage is not up to the level it should be. Undervoltage values result in the breaker tripping and staying out until the undesirable condition is corrected.

46

Phase-Balance Relays — These protect the system from faults occurring in any phase of a three-phase system. Quite often a fault current will not be large enough to trip the overcurrent relay but will operate the phase-balance mechanism, which is more sensitive, because of an unbalance in the three phases.

79

Automatic Reclosing Relays—These are used to automatically reclose electrically operated circuit breakers. They limit the duration of power failures in many instances where faults clear themselves quickly. Most reclosing relays attempt to close a breaker three times before locking it out. The time interval between reclosures is predetermined. Lock-out means that after the third attempt to keep the breaker in fails, the relay will not function until it is reset manually. Such relays can be designed to operate more than three times before locking out, with the number of reclosures depending on the requirements and design of the system.

With the wide variety of protective relays available today, no distribution system need operate without complete protection against faults. However, it is possible to overprotect a system or to have relays that will not operate under fault conditions if selection and arrangement have not been coordinated.

Meters

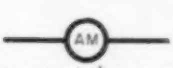
Meter

Indicating and recording meters or instruments are used to measure the different value of voltage, current and power in distribution systems.

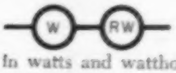
VM

Voltmeters— Voltage values need to be checked frequently to insure that an adequate voltage level is maintained. Voltmeters are used for this purpose and are connected in parallel or across the transmission lines. They measure the average voltage of the system and normally are of the indicating type which

shows the voltage level as it varies with the applied loads.



Ammeters – Current (amperes) is measured by ammeters connected in series with the transmission lines. They indicate the extent of the load the system is pulling and show whether or not it is overloaded.



Power Meters – Power is measured in watts and watthours, and when large quantities are consumed the units of measurements are kilowatts (*kw*) and kilowatthours (*kwhr*) and are derived by dividing the basic units by 1,000. Basically, there are three types of wattmeters: (1) indicating, which show the average rate at which power is consumed, (2) recording, which record the average value on special graph paper and (3) watthour, which sum up and record the total energy consumed during an interval of time.

Actually these meters consist of a voltmeter and ammeter combined. The voltage and current values are converted to power by means of voltage and current coils in the meter. They indicate the average power delivered to the system, and, are connected in the same manner.

Power-Factor Meters–Another value of importance that needs measuring is the power factor of the system. Meters for this purpose indicate the relation of the phase between the line current and line voltage which actually is the same as the power factor of the load.

Demand Meters–Still another value that must be measured is the rate at which power is consumed. Instruments or meters for measuring the maximum demand during an agreed period of time, usually a month, are known as demand meters. The demand or peak power is the maximum amount of energy consumed in any consecutive number of minutes, say 15 or 30 min, during the month. Demand is measured in kilowatts and is the average rate of consumed energy during the peak period. This method of establishing the maximum demand rate does not penalize the company for very short peaks. However, if the peak lasts the full set-time interval of the meter, a penalty would be imposed upon the company.

The next three components appearing in the one-line diagram are an oil circuit breaker, a disconnect switch and a lightning arrester. These have been discussed previously under their respective headings.

Overhead Pole Line

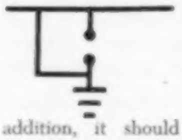
Most distribution systems include overhead pole lines even though, in some instances, they are short. The two-step voltage arrangement normally requires more overhead construction than the one-step system. Transmission of high voltage from main substation to intermediate substations often involves several miles of overhead power lines.

The following discussion on overhead pole lines will be limited to the electrical factors affecting the transmission of voltage (line reactance), grounding and lightning protection.

Line Reactance

Reactance, discussed in the section on AC theory, is caused by the inductive and capacitive characteristics of AC transmission lines. The spacing of conductors determines, in part, the amount of reactance in transmission lines which, in effect, causes voltage drop and poor power factor. Lines spaced far apart produce more adverse effects on each other than lines spaced close together. To reduce reactance, lines can be spaced closer together but this has its limits in overhead pole line construction.

Two other step factors help to reduce line reactance. They are the size and type of conductors with respect to radius and surface conditions. For the average mine setup, these two factors have very little effect on the amount of reactance in the system. Conductors are usually selected in accordance with the transmission distance and voltage level.



System Grounding and Lightning Protection – See discussion earlier in this report. In addition, it should be noted that a ground wire normally accompanies the power conductors, with lightning arresters installed at intervals of approximately 1,500 to 2,000 ft. The ground wire is connected to the ground side of the lightning arresters. This method has proved most satisfactory and is widely used in mine distribution systems, although it is not uncommon to find a system without a ground wire.

Intermediate Substations

Since most of the components included in the main substation are also used in the intermediate substation the reader is referred to that section of this report for a discussion of their purpose and application. It should, however, be noted that protection for intermediate substation should be as complete as the main substation. The rating of the components will be correspondingly less with lower voltage and load. Power-factor correction is the only major variation.

Power-Factor Correction

There are few AC systems that do not require power-factor correction. Correction can be made either at the substation for system correction, at the load for individual correction or both. This latter is not an uncommon practice. As a matter of fact, power-factor correction is being treated with as much importance today as any other phase of the power system. Once the money-saving potentials of power-factor correction are recognized, it will be applied to more systems. The saving is not in power bills alone but also in the reduction of load on the system which permits equipment to operate on a more normal power supply, thus reducing repair bills on the equipment.

The device most often used in mining systems to correct power factor is the capacitor. This, however, is not the only means. Other correction includes the use of synchronous motors, and the proper application of any induction motors.

Capacitors can correct and bring power factor up to 90 to 95%, which normally takes the mine out of the penalty area and reduces the reactive power in the system. Some systems may require overall correction and also correction at the center of groups of induction motors. Still other systems would require correction at only one of the two locations.

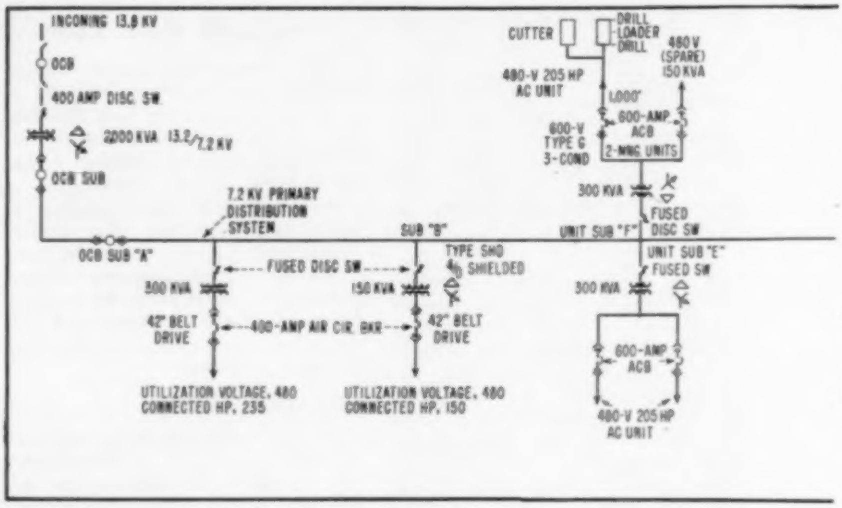
Correction at the intermediate substation consists of installing a capacitor bank with sufficient *ckvar* (capacitor kilovolt-amperes-reactive) to bring the power factor to the desired rating. The *ckvar* value is determined by the amount of *kw* and *kvar* of the system. From these values the *kva* and power factor can be calculated.

Shunt-type capacitors are used in most cases. They are made up of a group of conductors, usually plates, so arranged that, a large electrical charge can be stored in them. Electrical charges are stored when a potential difference exists between the conductors. Putting it another way, a capacitor stores electrical charges when the potential of the conductors is increasing and discharges it when the potential is decreasing.

Why capacitors actually correct power factor might be better understood if the inductance is considered positive and the capacitance negative. Thus, when capacitance (*ckvar*) is added to a circuit it subtracts from the inductance (*kvar*). Therefore, the *kvar*, or reactive power is reduced, which improves the power factor.

Portal Control Station

At this point of the installation there are several standards for distributing AC



MODERN AC MINE SETUP designed for 7,200-V distribution by Type SHD 4/0 shielded cable. Oil circuit breakers are equally spaced in the high-voltage line. Fused disconnect switches are placed on the high-voltage side of each power center.

power underground. These standards provide safety for men and equipment and contribute to an efficient underground distribution system.

The power should enter the mine as near the load center as possible for two reasons:

1. To reduce the amount of high-voltage cable underground.

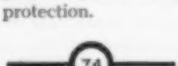
2. To minimize voltage drop between the substation and load center.

In most cases the substation—in this instance the intermediate, though it could be the primary unit in a one-step voltage-reduction system—will be located near the place where power is taken underground. Consequently, it is not necessary to provide an extra switching station equipped with circuit breakers and necessary protective relays, such as, overcurrent and phase balance, as well as ground-fault detectors and lightning arresters. The intermediate substation is equipped with these devices. On the other hand, if the entrance is located some distance from the intermediate substation it would be necessary to provide a separate installation including all the devices listed. These components were covered earlier in this report. However, the ground detectors are quite different, as indicated in the following.

Ground Protection

Protection of underground high-voltage systems can be achieved in several ways but probably the best method is the pilot-wire system employing the differential-type relays previously described. A small amount of line current is permitted to flow in the pilot wires through the secondary of current transformers. These pilot wires are carried with the power conductors.

Pilot-Wire Relays—Referring to the previous discussion of differential relays, these operate on a balance principle. The amount of current at one end of the line is the same as at the other end. When the current in the pilot wire becomes unbalanced, due to faults in the line, the relay operates and opens a circuit breaker. This method provides phase-to-phase as well as ground-fault protection.



Alarm Relay—An additional feature of this protective system is a relay for continuously checking the condition of the pilot wires. If the wires become short- or open-circuited, the relay will operate, indicating that the system is no longer protected against faults. The lines can then be inspected and repaired.

Underground Distribution

In conjunction with the surface switching arrangement, high-voltage cables entering the mine through boreholes or shafts are equipped with circuit breakers at the bottoms of these openings to interrupt power feeding into the mine in case of emergency and also for repairs.

Cables

Insulated multiple-conductor cables equipped with ground wires and a conducting shield over both ground and power conductor are used to transmit high voltage underground. Type SHD cables with adequate kilovolt rating are used in most installations. The length of these cables normally is kept to a maximum of 1,000 ft. They are connected by high-voltage couplers or potheads.

Couplers

From a safety viewpoint it is better to use couplers equipped with mechanical locking. This permits only authorized personnel to disconnect the couplers, and also eliminates the possibility of persons connecting them while repairs are being made.

Section Control Station

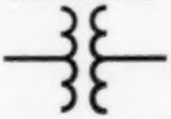
As transmission distances increase, it is necessary to sectionalize the cables at intervals of approximately 2,000 ft. This means that a circuit breaker or other disconnecting device is installed in the line at these intervals. This also applies to branch circuits that feed other sections of the mine. In addition to the circuit breaker these branch circuits should include necessary protective equipment of the same order as that required when the cables first entered the mine.

Load Centers

The high-voltage cable is terminated at the load-center with the same type of coupler used in the intermediate sections, with one half of the coupler permanently mounted on the load center frame. The power conductors are connected to the transformer and the ground wires are grounded to the frame.

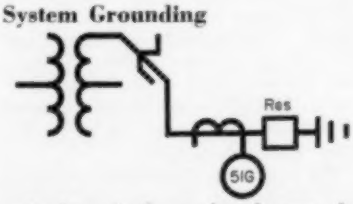
The purpose of the load center is to reduce the high voltage to actual utilization voltage and to provide switching and fault protection to the branch circuits that it will supply power to. It is a combination power and distribution center. However, individual units may be installed for the same purpose, although the combined unit seems to be preferred.

Transformers

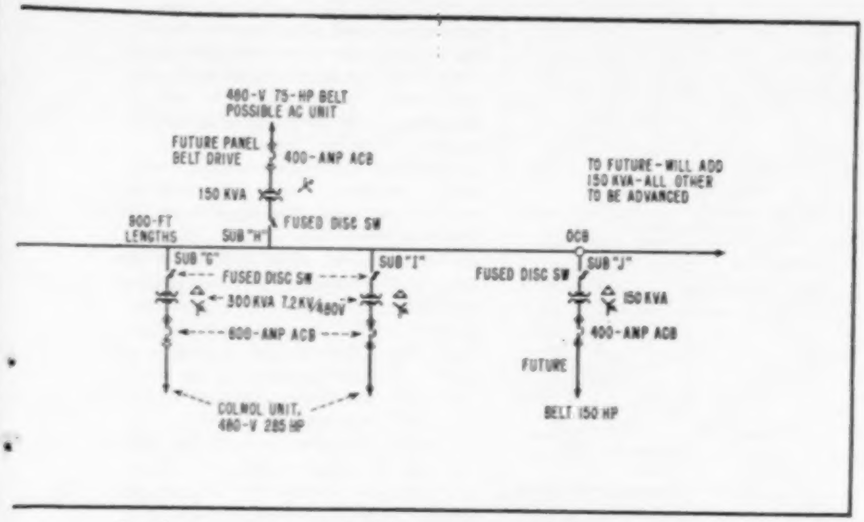


Dry air-cooled or inert gas-filled transformers can be used underground. The former are more widely used because, among other things, the liquid-filled units must have a separate split of air when installed underground.

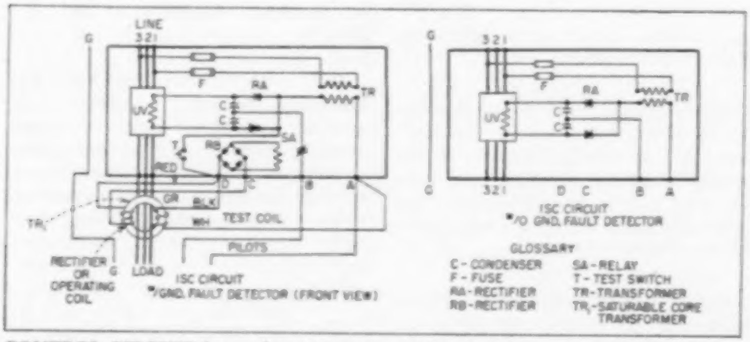
System Grounding



As shown in the one-line diagram, the transformer is connected delta-delta and uses a zigzag grounding transformer to establish a neutral. The neutral is re-



Transformers are connected "delta-wye" for grounding purposes. Air circuit breakers of the proper rating are provided at the load center. The system provides protection for men and equipment.



CONTROL CIRCUIT for modern AC system with and without ground-fault detector.

sistance grounded and contains the same ground relays as the intermediate substation.

Circuit Breakers

Back-up protection is provided for each branch or bus circuit by installing a breaker between the transformer and bus. This gives added protection when relays are properly coordinated. It is, however, possible for both breakers to trip at the same time which would cause a delay in the other branch circuits. But, in most instances, when a fault occurs in any one branch it will trip only the branch circuit breaker and not disturb the others.

Circuit breakers used most often in underground load center are of the stationary mounted molded-case type but other types also are used. They can be equipped to provide overload, overcurrent and undervoltage protection.

Relays

Protective relays accompany main as well as branch circuit breakers. The relays employed in load centers provide overload, overcurrent and undervoltage protection.

Overload Relays—These are used to protect the branch circuits against overloads growing out of motor operation. The tripping device is built into the circuit breaker. Instantaneous overload generally will not trip the breaker but overloads lasting for several minutes will result in interruption.

64 **Overcurrent Relays** – These are used for ground-fault protection. They require the use of current transformers and an established ground conductor in each individual branch circuit of the portable cable supplying power to face equipment.

To obtain ground protection in each branch circuit, current transformers are connected in each phase of each branch. The most effective and accurate current transformer for this application is the loop or ring unit. They are not as sensitive to small unbalanced phase loads as other types. Ground faults, on the other hand, cause unbalanced currents to flow, which operate the relay and in turn open the circuit breaker.

27 **Undervoltage Relays** – These are used primarily because AC motors do not operate efficiently on low voltages. The relay serves as a signaling device to warn operators that the voltage is not sufficient for good motor performance. When this condition exists, the obvious solution is to move the load center closer to the center of operations in the active mining zone.

Voltage Regulation

Due to the high starting currents of AC induction motors, it is often desirable and sometimes necessary to install capacitors at the load center to maintain a good power factor and to compensate for voltage drop during the starting period. The benefits of capacitors will in most cases, offset the cost of installing them. Power factor correction, discussed earlier in this report, would also apply.

Meters

VM AM The only measurements of power that would be of benefit at the load center are voltage and current. Whether these values should be measured in each branch or bus circuit is a matter of choice. This information, in many instances, can be of value with respect to the operation of the face equipment.

Utilization Distribution

The elements of concern at this point in the distribution system are cables, couplers and ground continuity. Once cables and couplers are installed, the only everyday task remaining is checking ground continuity. This is vital if safety for men and equipment is to be maintained.

Portable cables used in AC utilization are normally Type G—a three-conductor cable with an insulated ground conductor. Cables usually are sectionalized in 50- and 100-ft lengths so that their bulk will not be excessive. Keeping cables short helps to reduce voltage drop.

Couplers attached to the ends of the cable sections should be designed to prevent injury to persons connecting and disconnecting them.

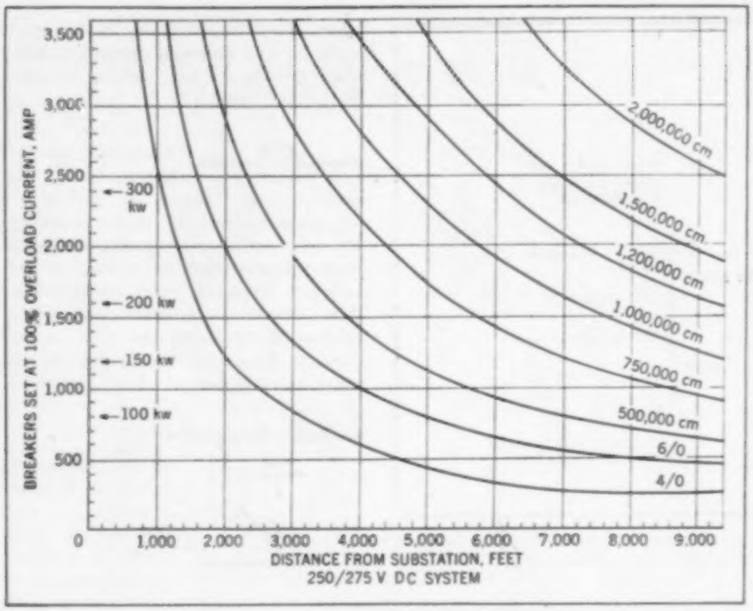
Ground-continuity checking devices are difficult to maintain in portable cables, especially those that are spooled

feeder, aluminum has about 70% the current-carrying capacity of copper, and 3 ft of aluminum feeder can be bought

Unit Resistance of Common

Face Preparation *(Continued)*

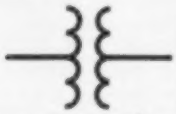
that each hole should "relieve" the next



LIMIT OF CURRENT FLOW in a DC circuit at various distances from substations for various sizes of conductors is shown in the above chart.

on reels. To date there is no effective way of checking this operation other than by test by maintenance personnel.

Lighting Transformers



Power for section lighting can be obtained from the main load center transformer or by a separate transformer installed for that purpose only. When the main transformer is used a voltage stabilizer is needed to reduce flicker which is caused by fluctuating loads in the system. Consequently, a separate source is more desirable since it is independent from the power system and provides a constant voltage for lighting.

DC Service

Plan conversion equipment installation to meet the increasing power demands of equipment.

Weigh the possibilities of converting manual substations to automatic controls.

Provide sufficient feeder capacity and stay within maximum transmission limits.

Have DC system sectionalized.

Conversion equipment includes the old-reliable converters and m-g sets, but the standard unit today is the mercury-arc rectifier, including the glass-bulb type. A few metallic rectifiers of the selenium type are in service and units based on germanium, silicon and other metals are under consideration for possible use in the future.

CONVERSION CAPACITY – Higher horsepower per machine and per section is requiring an increase in the capacity of rectifiers and other conversion equipment. A recent series of tests on power required by continuous miners indicates that the capacity for a single section (miner and shuttle cars, roof drill, etc.) should be at least 200 kw.

Dull bits on miners and other equipment have a major effect on power demand and consumption. In one test with dull bits, miner advance was 20 ft, demand was 82.4 kw and consumption was 32.47 kwhr. Time was 50 min. With sharp bits, advance in 54 min was 30 ft. Demand was 69 kw and consumption was 31.33 kwhr (J. O. Cree, 1956 Coal Convention, American Mining Congress).

AUTOMATIC OPERATION – The high cost of labor naturally dictates making substations automatic unless attendants can grind bits, splice cables or perform other duties. Equipment now is available for checking position and operating breakers at will from a central station several miles away (*Coal Age*, October, 1955, p 68). The system is based on carrier current using telephone lines for transmitting audio signals.

PORTABILITY–For the maximum in convenience and efficiency, the trend is toward portable conversion units. Such units also may be placed in permanent locations–to serve main-line haulage, for example. Or stationary types may be employed at some saving in cost.

Portability facilitates keeping transmission distances short. However, if the cover is shallow, some mines have felt that the lower cost of pole lines and surface facilities, even when offset by the cost of boreholes, warranted keeping conversion equipment on the surface, even with 275 V as the nominal voltage. With 550 V, the reduction in number of moves otherwise necessary is an added reason for considering keeping conversion equipment outside.

Heavy locomotives bring up the problem not only of placement and capacity of substations but also the effect on the remainder of the system as the locomotive passes a given point. To reduce disturbance in face operation as a result of locomotive operation, substations may be equipped with automatic load distributors.

THE INVERTED TROLLEY–For locomotive operation, a newcomer in service is the inverted trolley (*Coal Age*, October, 1952, p 87). As the name implies, the trolley is placed on top of inverted hangers, and the locomotives receive power through sliding shoes pulled by cables.

Transmission Limits

The maximum distance DC can be transmitted from the substation depends on a number of factors, and must be calculated for each individual operation. Balancing everything, the distance should not exceed 3,000 to 3,250 ft for an 800-amp average transmission, 300 V at the nips and 250 V at the machine.

Even with the maximum in feeder capacity it is difficult to maintain adequate voltage, let alone rated, for 250-V motors at distances much over 4,000 ft. Incidentally in increasing feeder capacity, it is better to use a number of smaller cables than one large one because the current-carrying capacity is greater. At 30C ambient temperature, 45-deg rise, for example, approximate ratings are: 500,000 cir. mils, 800 amp; 1,000,000 cir. mils, 1,230 amp; 1,500,000 cir. mils, 1,550 amp.

ALUMINUM FEEDER–A decidedly lower relative cost makes aluminum very advantageous for bare feeders alongside trolley wires or elsewhere. It has greater bulk, however, and consequently the advantages are largely offset by the increased insulation and jacket when used for high-voltage power cables or low-voltage trailing cables. But with bare

feeder, aluminum has about 70% the current-carrying capacity of copper, and 3 ft of aluminum feeder can be bought for the price of 1 ft of copper.

EDISON SYSTEM—One possible answer to the problem of keeping substation moves down while keeping voltage up is the three-wire, or Edison, system (*Coal Age*, July, 1947, p 86).

Sectionalization

Safety, quick isolation of fault areas, and quick replacement of damaged facilities are among the benefits of sectionalization. The latter applies particularly to the growing custom of using short lengths of cable with push-pull connectors in distribution of power at the face. Connector design is such that power is removed before the circuit is opened.

Recommended sectionalizing practice may be summarized as follows:

1. Provide in every instance sufficient capacity in the feeder and return so that the most remote dead short will open the overcurrent protective device, usually an automatic reclosing circuit breaker.
2. Install an overcurrent protective device in the circuit between each two substations at a point where resistance both ways is equal. If enough copper is used so that a ground at any point will open the protective devices at both substations, no intermediate protection is necessary. A section insulator, or "dead block," may be used between substations if they need not be paralleled.
3. Insert a disconnecting switch or protective device at intervals of not over 1,500 ft in all power lines.
4. Install an overcurrent-protective device in each circuit leaving a substation—fuses, or manual or automatic-reclosing circuit breakers. Circuit breakers should have trip-free operating mechanisms. The exception is where a substation feeds only one haulage unit, in which case only one station breaker is required.
5. Place an overcurrent protective device at each branch circuit.
6. Protect each circuit feeding a local section or territory with an overcurrent device.
7. Install overcurrent protection at the supply end of each circuit to pumps or other fixed loads.
8. Install switches to cut power off unimportant and infrequently used branch or stub circuits.
9. Protect each mining setup with an overcurrent device.
10. Keep overcurrent circuit-breaker settings or fuse ratings as low as practical for good operation. Specific settings are listed in a discussion of the subject in *Coal Age*, November, 1953, p 86. How to calculate load division as a guide to choosing breaker settings is detailed in *Coal Age*, August, 1955, p 55.
11. Cut power off all idle territories during non-operating times. If it is necessary to run a pump or some other one unit, special overload protection no greater than needed should be provided.

Unit Resistance of Common Sizes of Copper Wire and Steel Rail

COPPER WIRE

Size, CM	Resistance, Ohms per 1,000 Ft
1,500,000	0.00719
1,200,000	0.00899
1,000,000	0.0108
750,000	0.0144
500,000	0.0216
300,000	0.0360
211,000	0.0509

STEEL RAIL

Weight	Equivalent Each Rail, CM of Copper	Resistance, Ohms per 1,000 Ft (both rails bonded and cross-bonded)
30	300,000	0.0180
40	400,000	0.0135
50	500,000	0.0108
60	600,000	0.0090
70	700,000	0.0077
80	800,000	0.0067
90	900,000	0.0060
100	1,000,000	0.0054

Ground Protection

The solid wire from machine frame to ground provides protection to men from short circuits—under most conditions—but no protection to the machine. Thus, some other provision is necessary. The original unit, still widely used, was the fuse, either in the junction or distribution box or in the trailing-cable nip. A major disadvantage is that a ground fault of low intensity, say 100 amp, is not sufficient to blow a fuse—or operate a circuit breaker—rated or set at 200 amp.

The best answer to this latter condition is a three-pole circuit breaker, with one pole in the grounding circuit equipped with a 5- or 10-amp current-limiting relay. A low-intensity fault will trip the breaker as a signal for corrective measures, while a high intensity fault will be cut off before severe equipment damage occurs.

Proposed alternatives, particularly for such mobile units as shuttle cars, include the polarized relay, the polarized short-circuiting device and certain electronic devices (*Coal Age*, February, 1955, p 84). [END]

Face Preparation *(Continued)*

that each hole should "relieve" the next. A second is that the burden on each hole should be adjusted to the maximum charge that can be loaded, though this maximum does not have to be the legal maximum. Consequently a common pattern is a row of holes in the top in thin coal, or in the top and middle in thicker coal, with the center hole shot first in the bottom row in two-row faces, and in the top row in one-row faces.

Modifications are numerous. One, as an example, is a row of holes immediately over a slate parting low in the seam to smash it and relieve the regular holes. Another is the snub shot, which may be a full-length hole in or close to the center to knock down the lower part of the cut and open up the face for the subsequent holes. As a variation, the snub hole may be drilled only part way in to break down and roll out the front of the cut. Bottom and snubbing holes may be angled down to get better breakage at the back and more force to kick the coal to the front.

Concentration may be sought for or avoided. As an example, the benefits of drilling a smaller hole may be more than offset by the stringing out resulting from use of smaller cartridges, thus preventing sufficient concentration of force to break the coal properly and economically. On the other hand, concentrating the force at the back of a deep cut in thin coal may result in the charge breaking down to the kerf in the back and leaving the front standing. One remedy is a slower-acting medium in more of the hole.

Charging and Firing

Stemming always is used with conventional explosives, but normally not with steel-tube blasting devices. However, instead of stemming, safety regulations in some regions require setting safety barriers or deflectors against each hole or the entire face to eliminate flying tubes. In lieu of conventional stemming, blasting plugs may be employed with explosives to save time. Conventional stemming includes the plastic clay dummy made by extrusion and available from extrusion specialists in many areas.

Single-shot firing with electric detonators still is the predominant system in the coal mines. However, it has definite disadvantages, one of which is the fact that the shotfirer is constantly exposed to the hazards of loose roof and must work in considerable smoke and dust in connecting to each charge after the first. As a result, there has been a substantial increase in millisecond delay ignition of shots in sequence. There is equal safety in relation to gas and dust, less chance of overbreaking exposing the following charges, less shock to the roof, and much less exposure hazard for the shotfirer.

THE FOUNDATION of a successful strip operation lies in sound planning

Practice Trends

The Strip-Mining Guidebook

THE FOUNDATION of a successful strip operation lies in sound planning well in advance of the time a mine is opened. Planning is becoming increasingly important each year as the cost of opening a new mine grows and the pressure mounts for keeping operating cost as low as possible. What are the items which must be planned and who should do the job? Since an efficient strip operation demands the combined efforts of engineers and operating officials, both should contribute to the basic planning. But most of the work will fall on the shoulders of the engineers because most of the ground work involves engineering problems. Once the basic planning is completed, operating men must see that they are carried out.

Planning the Operation

Buy or option enough land to provide maximum continuity of operation if opening in a new area.

Recheck boundaries and mining rights of property already owned.

Prepare work maps on which can be shown property lines, coal outcrop if any, borehole locations, coal thickness and depth of cover.

Prospect the area by drilling and outcrop openings if possible. Put this information on the maps.

Chose a plant site that is as centrally located as possible so haulage distances will be as short as possible.

Plan and lay out a permanent haul road between plant and pit, taking care to get good alignment and grades.

Select equipment that will do the best job in the natural conditions. Make sure that all machines have matched capacity for an efficient production cycle.

Check markets and decide type and extent of coal preparation.

Practice Trends

Stripping machines continue to grow in size as first 70-yd shovel proves itself at 2-million ton mine and other similar units get ready for operation.

Dragline size reaches new high as 35-yd machine goes to work in anthracite pit.

Capacity of two-crawler draglines increases to record 10 cu yd in unit featuring faster operation.

Big bulldozers continue as stripping units in areas with thinner cover.

Hydraulically controlled rippers mounted on the rear of powerful tractors pass test as coal breakers.

Progress continues in big-truck design with application of individual wheel supports for tractors and trailers, use of alloy steel in trailer construction to reduce weight and a thermostatically controlled engine-cooling fan requiring only one-third as much power.

Automatic braking devices continue making gains on trucks operating on severe grades.

First commercial horizontal rotary dry-type overburden drill bores 9-in hole 48 ft deep with one drill stem.

Mechanical loading and tamping of horizontal blastholes conserves manpower and increases flexibility of operations.

New variations and improvements in mixing and detonating make-your-own blasting agents continue to appear.

Blow charging of explosives into blastholes undergoes additional trials with commercial unit at strip mines.

Future Possibilities

Construction of an 80-yd shovel and a 40-yd dragline in the foreseeable future, possibly within 5 yr.

More refinements in blasting agents and use of non-sensitive primers.

Introduction of the 100-ton coal hauler, through use of more alloys and new design techniques plus more powerful engines.

GETTING THE LAND—The type and scope of engineering work in planning a new mine depends on the conditions at each property. For example, if a company already owns land suitable for strip mining, less work is needed than if a company plans to open a mine in an unfamiliar area.

When going into a new area it is especially important for a company to be careful in taking steps to acquire land. Sometimes the asking price for land skyrockets as soon as word gets around that a new mine is being planned. As a result, the company finds that land has doubled or trebled in price. And the cost of opening a new mine rises accordingly. To forestall this problem as much as possible, it sometimes pays to hire a local agent to buy or option land needed for a new development.

The area of the land that can be acquired or conveniently assembled into a mining property determines to a large extent the type of operation that can be planned. But regardless of the size of the property it is very important to learn as much as possible about the land—who owns each tract, what the restrictions are and what the going price in the area is.

CHECKING THE COAL—Once the land buying is under way, steps should be taken to accumulate information about the coal and the material covering it. This is an engineering job and should include surface surveying to provide topographic information plus prospect drilling to gain information about the coal bed. As rapidly as the information is accumulated it should be sent to a central office or responsible engineer for recording and analyzing. Certain questions about land ownership, mineral and mining rights, coal thickness and quality, type and thickness of overburden can be expected. They can be answered much easier if all information is accumulated at a central point and organized for ready reference.

ing faster and more economically than

LOOK AT MARKETS—Another important factor in developing a new strip mine is knowing the possible markets for the coal. This is important because mining methods and preparation needs frequently are influenced by the market to be served. For example, the same type of preparation facilities may not be needed for processing coal for the metallurgical market as for the utility and industrial markets. The type of market served also may influence pit operations. Regardless of the market to be served, planners must be sure that enough land is available for building a modern preparation plant.

PLAN RECLAMATION — Another problem that is demanding more attention today is restoring the spoil areas to usefulness after mining is completed and preventing stream pollution. There is a definite need to restore the land but the type of restoration work depends on the topography and the type of material in the spoil bank. Sometimes the only immediate steps that can be taken are backfilling and leveling according to law requirements because the material will not support vegetation until it has weathered for several years. Before any restoration work is started, the material should be analyzed.

Equally important as studying the engineering and operating problems is making sure that adequate financing is available. This is necessary if the property is to run efficiently, the customer to be served properly, the owners given a fair return on their investment and the land left in condition that will serve a useful purpose in the future.

Mapping

Accurate maps in the hands of competent engineering and operating supervisors can provide a solid base for planning development, day to day operation and equipment moves. Modern techniques, including aerial surveying, make it possible to obtain accurate maps at only a fraction of the cost 10 to 15 yr ago. The aerial survey is especially valuable in mapping large areas in a minimum of time and is rapidly replacing the slow, tedious ground survey.

An average topographic map can be made up in one-half to one-fifth the time needed for ground surveys at a lower cost and with no sacrifice of accuracy. With an aerial topographic map, an engineer can estimate coal acreage, plot crop lines, spot boreholes, determine and locate spoil areas, lay out haulage roads, compute overburden ratios and plot property lines.

When it is not practicable or desirable to have an aerial survey made, a ground survey may be required. The extent of the survey will depend on the lay of the land and how much information is already available, such as, topographic maps and geologic bulletins. If deep mining was done in the area, mine maps will provide a valuable source of information and will reveal a great deal about the nature of the coal. First, they will show how much, if any, coal is left between mine workings and the outcrop. Seam characteristics, including dip, thickness, unusual conditions and so on probably will be shown.

Prospecting

Information about the coal seam and conditions which might influence mining methods should be accumulated as soon as possible after basic maps are prepared. Drilling is the most satisfactory method of prospecting coal for full and accurate information. This can be done either by churn or diamond equipment. Diamond drilling provides a core section of the overlying rocks and the coal, and therefore yields very valuable information. A churn drill in the hands of a skillful operator also can provide accurate data but results depend on the skill of the drill operator. A coal core, on the other hand, can be examined visually and half of it sent to the laboratory for complete analysis. The other half can be kept for reference.

Development of a bottom-discharge bit that prevents air circulation around

Operating

Stripping and Augering—A three-pronged attack with shovel, dragline and augers nets 40,000 tons per month. Ammonium nitrate and fuel oil packaged in water repellent bags cuts blasting costs. *Coal Age*, July, 1957, p 60.

Big Shovel Performance—A faster cycle and higher hoisting speeds result in higher efficiency in thicker overburden. In 1956 The Mountaineer handled an average of 74 ft of material. Cycle time was 57.63 sec and average digging time was 83.46% of available time. *Coal Age*, August, 1957, p 72.

Prospect Drill Cuts Own Road—Exploration work in rugged terrain where a truck-mounted drill could not go is speeded with a rotary unit mounted on a tractor with a bulldozer blade. *Coal Age*, August, 1957, p 92.

Two-Seam Stripping—Faster dragline designed especially for two-seam stripping swings 10-cu yd bucket and is reported to be the largest on two crawlers. Two other draglines help expose 3,500 tpd. Loose ammonium nitrate granules mixed with fuel oil poured directly into blastholes used experimentally to cut blasting costs. *Coal Age*, September, 1957, p 74.

Mechanical Tamping of Blastholes—With the aid of a new mechanical loading and tamping device for horizontal holes, one man in four days, single shift, does what it took two men five and six days to do. Greater flexibility in pit operations is an added benefit. *Coal Age*, September, 1957, p 88.

Dry-Type Horizontal Drill—A new crawler-mounted unit sinks 9-in horizontal holes 48 ft deep at a rate of 50 in per minute without adding drill sections. In best shift, one man drilled 816 ft of 9-in hole. *Coal Age*, October, 1957, p 98.

Mountain Top Stripping—A 12-cu yd dragline and a shovel converted to a 6-cu yd dragline extend stripping range. Efficient drilling and blasting is achieved with rotary vertical unit mounted on a crane-carrier-type all-wheel drive chassis and ammonium nitrate and fuel oil blasting agent. *Coal Age*, December, 1957, p 58.

Handling Blast-Damage Problems—Successful defense against blast-damage claims is possible, but heading off claims should be emphasized. Positive evidence as to the real cause of damage, presented by qualified, experienced authorities is the best defense to claims. *Coal Age*, December, 1957, p 76.

70-Yd King of Spades—World's largest shovel takes 70-yd bite every 50 sec in 70-ft cover. Unit uncovers coal at the rate of 2 million

tons per year. Design features include use of 7,200-V power, all-welded construction and the use of high-tensile alloys in the front end to provide maximum strength with minimum weight. *Coal Age*, January, 1958, p 76.

Drill on Shovel Boom—A horizontal drill mounted on a shovel boom places 6-in holes in limestone 15 ft above base of overburden, thus making possible more efficient use of explosives. *Coal Age*, January, 1958, p 136.

Cables for Strip Mines—Application limitations, most frequent causes of failure and steps to take for better maintenance and longer life. *Coal Age*, February, 1958, p 140.

Ripping Coal for Loading — Hydraulically controlled rippers mounted on the rear of powerful tractors can break coal seams up to 6 ft thick. At one Illinois mine, use of ripper resulted in daily saving of $209. *Coal Age*, February, 1958, p 148.

Cooling System Care Pays—Steps to take in checking cooling systems of diesel engines of earthmoving machines. *Coal Age*, February, 1958, p 170.

Eight-Step Contour Stripping—Up to 95 ft of cover is moved to mine a total of 13 ft of coal from two seams. Augering increases recovery of coal from both seams after stripping limit is reached. *Coal Age*, March, 1958, p 90.

Water-Powered Device Treats Acid Water—A new automatic lime-feeding device requiring no power other than the water itself keeps water treating cost to a minimum in isolated areas. *Coal Age*, March, 1958, p 148.

Bulldozer Stripping, Highwall Augering—Big bulldozers remove cover without aid of explosives, keeping stripping cost to a minimum. Auger adds 125 tpd from irregular seam. *Coal Age*, April, 1958, p 116.

Revolutionary Torch Cuts Shovel Repair Cost—Physical melting and air blasting are combined to remove worn hard-surfacing in preparation for re-surfacing in 10% of time formerly needed. *Coal Age*, April, 1958, p 144.

Percussion Unit Drills Hard Rock—Down-the-hole drill with carbide-tipped 6½-in bit sinks holes for second-cut anthracite stripping with 6- and 8-yd draglines. *Coal Age*, May, 1958, p 114.

New Rope Clamp Cuts Downtime—A split-wedge-type grip for 2½-in hoist ropes eliminates downtime caused by failure or slipping at the clamp. A 5-ft increase in dumping height for 60-yd shovel is added benefit. *Coal Age*, June, 1958, p 88.

the core has made possible the successful application of air core drills. Air coring is said to make possible 100% core recovery nearly every time, even when it is necessary to stop half way through a seam. In soft, friable coal at least a 4x5½-in core barrel is needed to prevent the core from breaking and falling out. A very important advantage of air coring is that thin, soft partings of clay or other material are not washed out as they would be when using water. Another advantage is that water lines and pumps are eliminated.

RECORDING DATA—In any drilling program, sufficient holes should be drilled to get an accurate picture of the coal bed. The drilling results should be plotted on the property map along with other key data. Isothickness lines should then be added to the map.

These lines will show how thick the coal is in the various areas and along with surface contour maps will be useful in computing overburden ratios. Coal-thickness contours plotted on a property map are especially helpful when the coal bed is irregular.

If the coal bed outcrops, prospecting should be done at regular intervals along the outcrop. The modern tool for this job is the bulldozer. Once the bulldozer is on the outcrop, it can make an opening faster and more economically than by hand methods. Outcrop openings and trenches extending above the coal bed, can yield other useful information on the type and nature of the rock covering the coal and how much outcrop coal must be removed before merchantable coal is reached.

As prospecting information is accumulated, it should be put on a prospecting and property map developed from a topographic map base. As the picture on the prospecting map takes shape, decisions can be made as to where more prospecting is needed and how much.

Choosing Plant Site

If a new preparation plant must be built, the first job is to pick a site for it. Choice of a location is governed by access to rail facilities, suitable building space and nearness to the coal to be mined. Where possible, the plant should be centrally located so haulage distances will be as short as possible.

After the plant site is chosen the point to attack the coal seam should be selected. Then a permanent haulage link should be laid out to connect the preparation plant with the pit. A preliminary road layout can be made on a topographic map, along with estimates of the earthwork involved in building it. The field work then will consist of marking off the road route, grade and making any minor adjustments.

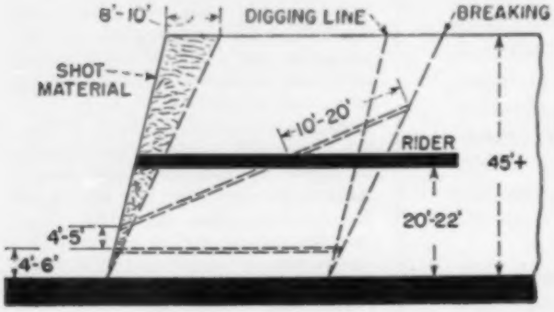
In arriving at a permanent road layout, it should be remembered that good alignment and grades will pay off in faster haulage and lower truck maintenance. A solid, well-drained roadbed should be standard practice in all road design. Trucks should be able to travel at top speed whether loaded or empty, and drivers should be able to see clearly on all curves.

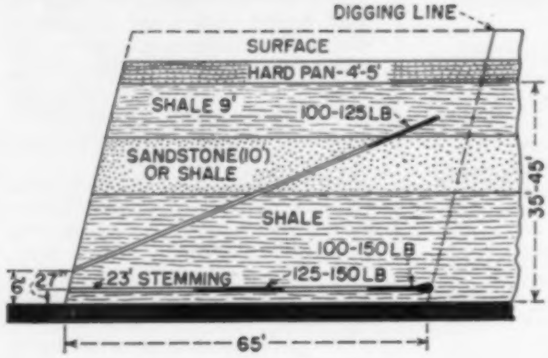
MINE LAYOUT—The mining plan will be governed by a combination of factors: type, thickness and contour of the overburden, as well as thickness, quality and the quantity of coal available. If the coal lies below drainage, a box cut will have to be made to gain access to it. If the coal is to be mined by following the contour or outcrop, a considerable sum of money may have to be spent to build roads to the coal level. If it is not desirable or feasible to haul coal downhill to the preparation plant, a bin, feeder and conveyor setup will be needed at the dumping point to link it and the cleaning plant. The final selection of method will have to be made after a careful analysis.

Selecting Equipment

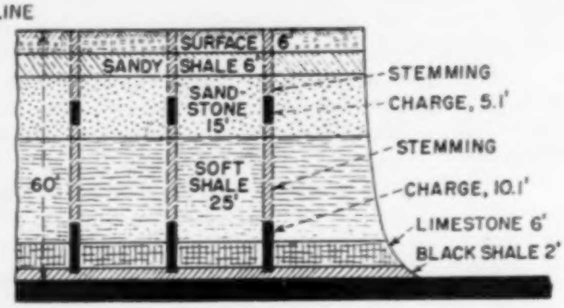
Closely linked to the mine layout is the selection of equipment for all phases of the operation. Natural conditions along with economic factors will largely deter-

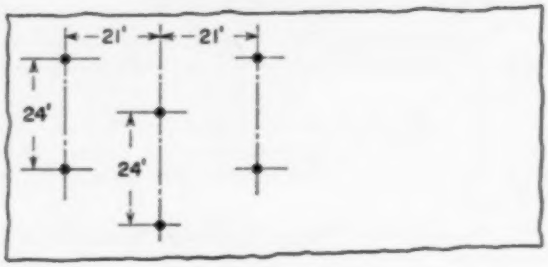
How Some Operators Tackle Unusual Shooting Problems



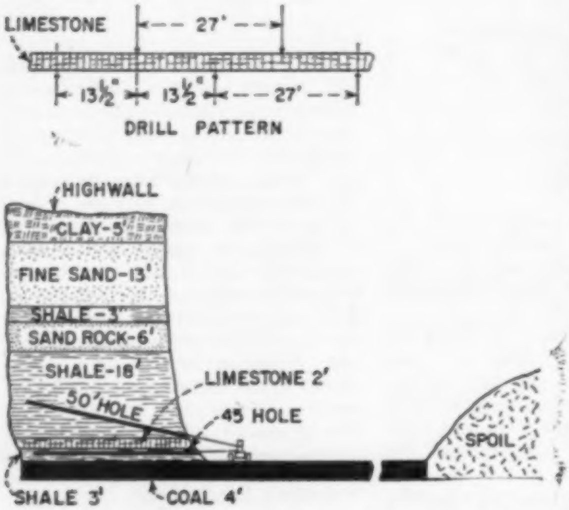


HOW DOUBLE-DECK SHOOTING can be used to break banks with hard or tough materials in the top. In the plan at the bottom, use of two holes reduced fine coal output by 10%, cut the quantity of explosive needed and enabled the dragline to work to the full depth of the holes, thus gaining 5 ft on each cut. In the system shown at the top, the explosive charge in the upper hole is brought farther toward the front of the bank and to provide sufficient resistance a layer of shot material is left.

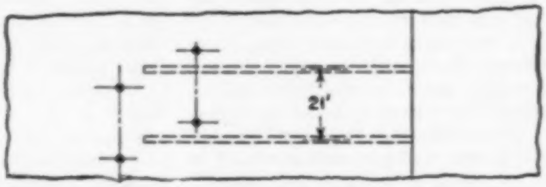




BLASTING the highwall is a tough job in this pit. Holes are drilled in diamond pattern and explosives are concentrated in hardest layers of rock. By placing separate charges in the hard sandstone and limestone layers, explosives are used most efficiently and better fragmentation is achieved. Changes in thickness of either the sandstone or limestone are watched carefully and the quantity of explosives is increased or decreased as required. Accurate logs of all blastholes are kept to serve as a guide in loading explosives.



ALTERNATE HOLES are drilled above and below thin layer of limestone in this pit. The aim is to get complete breakage of hard layer at bottom as well as good fragmentation of thicker material above.



THIS RATHER UNUSUAL JOB of highwall shooting features vertical holes to the limestone to break it so the horizontal shots can heave the overburden the full depth of the horizontal holes. All shots in or near a vertical plane through the horizontal hole are fired together. The farthest-in vertical hole is slightly beyond the bottom of the horizontal hole.

mine the type and size of equipment to be used. The key question will be how many cubic yards of overburden can be economically handled to recover a ton of coal. Today there is no simple or magic formula that can be applied to determine the economic stripping limit. A realistic estimated cost is the best guide. When the stripping limit is determined, equipment capable of working to that depth can be considered.

ESTIMATING MINING COST—Estimated cost should include a complete breakdown according to the accounting procedure that will be followed when the mine is operating. For example, labor and material costs should be carefully estimated for such things as drilling, shooting, stripping, explosives, pit cleaning, coal loading, road building, fuel, oil and grease, maintenance, supervision, depreciation and any other items necessary to arrive at fairly accurate estimated mining cost.

CHECKING EQUIPMENT RANGES—To help in the selection of stripping equipment, it is wise to draw profiles of the proposed stripping area along with equipment dimensions and ranges. This type of diagram will show how wide the pit can be made, what the spoil bank will look like and how each type of equipment can be used most efficiently. Some of the factors affecting the selection of key stripping units will be the tonnage of coal desired per shift, surface features, available spoil area and type of overburden.

The reserves of coal available for stripping also will play an important role in the selection of equipment. There must be enough coal owned or under lease to permit amortization of the capital investment over a reasonable period of time. It could be unwise to develop a mine with small-capacity equipment when there are ample reserves that can be recovered more economically with high-capacity units. Contrariwise, it would not be good judgment to buy big expensive machines if there are not sufficient reserves to set up a reasonable depreciation rate. Before making a decision on the type of equipment it is sound policy to have a series of meetings between engineering, operating and manufacturer's representatives to consolidate ideas.

BETTER ENGINES—More efficient engines for tractors, trucks and stripping machines now are available in the form of turbodiesels. A turbodiesel is a conventional diesel engine to which a turbocharger has been added to convert wasted power in the exhaust gases into useful energy. By forcing more air into the cylinders, the turbocharger makes possible more efficient burning of a greater fuel charge, thus creating more horsepower. Advantages cited for the unit include more work on the same quantity of fuel; more power, which makes possible better performance; and more power per pound of engine. As a result of the increased power in the new diesels, output of units powered by them is constantly being increased.

In any operation it is wise to consider the needs of a specific mine in relation to over-all efficiency and cost rather than merely in terms of dirt-moving capacity. Continuing growth in size and earthmoving ability of new and bigger machines are the result of the industry's demand for these machines. But there also still remains the need for medium and smaller size shovels and draglines.

MOVING COST—First cost is not the only expense involved with a stripping machine. It must be erected on the job and perhaps torn down and moved to a new site. Mounting labor costs must be given careful thought in the moving and erection costs of equipment. These two indirect costs alone may set an economic limit to the size of the unit because it is not always possible to amortize equipment during the life of an operation. Where it is not feasible to do this, medium and smaller size machines have the added advantage of low-cost moving to another location.

If the acreage or reserves of mineable coal is not large enough to justify the purchase of a large dragline or shovel, the ability to move a unit to a new site becomes an important factor in equipment selection. Mobility is particularly desirable for small or medium size companies in acquiring new coal reserves, especially in areas where large strip areas no longer are available.

BALANCE UNITS—Once the capacity of a mine has been decided upon through the selection of stripping equipment, other units, such as drills, coal shovels and trucks should be selected to build a balanced production cycle. After the production cycle is established, any change in one of the cycle components will upset the balance. Unless other changes are made, inefficiency will result.

It is sometimes practicable as well as economical to add flexibility to the operation by adding a small or medium size shovel or dragline. For example, a small machine sometimes can be used profitably to remove the cover in a tandem operation when a large shovel or dragline takes the major portion of the overburden.

RADIO COMMUNICATION — Where mining plans call for the various machines to be working far apart or in more than one pit, strong consideration should be given to installing a radio communication system. Money spent on the radio setup frequently can be repaid in better supervision and less equipment down time. For example, time lost by equipment in the pit can be substantially reduced because stripping units can report trouble immediately. Thus repair crews and facilities can be called to the scene promptly. If the job requires parts or materials not on hand, they can be ordered from the warehouse in a matter of seconds merely by picking up the microphone and calling. If an emergency order for a part must be sent to the factory, word can be sent to the mine office and immediately relayed by phone to the factory. Frequently the part can be on the way to the mine by plane in less time than it would take to drive from the pit to the office to telephone.

Another important benefit of radio communication is that supervisory efficiency can be improved considerably by reducing the time needed to cover the ground to check operations. With radio, much of the routine of checking on the progress of stripping and pit conditions can be done by calling the pit, thus reducing supervisory driving to a minimum and leaving more time for planning.

Overburden Preparation

Choose hole size to get effective distribution of explosives within strata.

Select drilling pattern to permit most effective use of explosives.

Log drill holes to guide shooters in charging the holes.

Consider mixing your own explosives as a way to cut the cost of breaking rock.

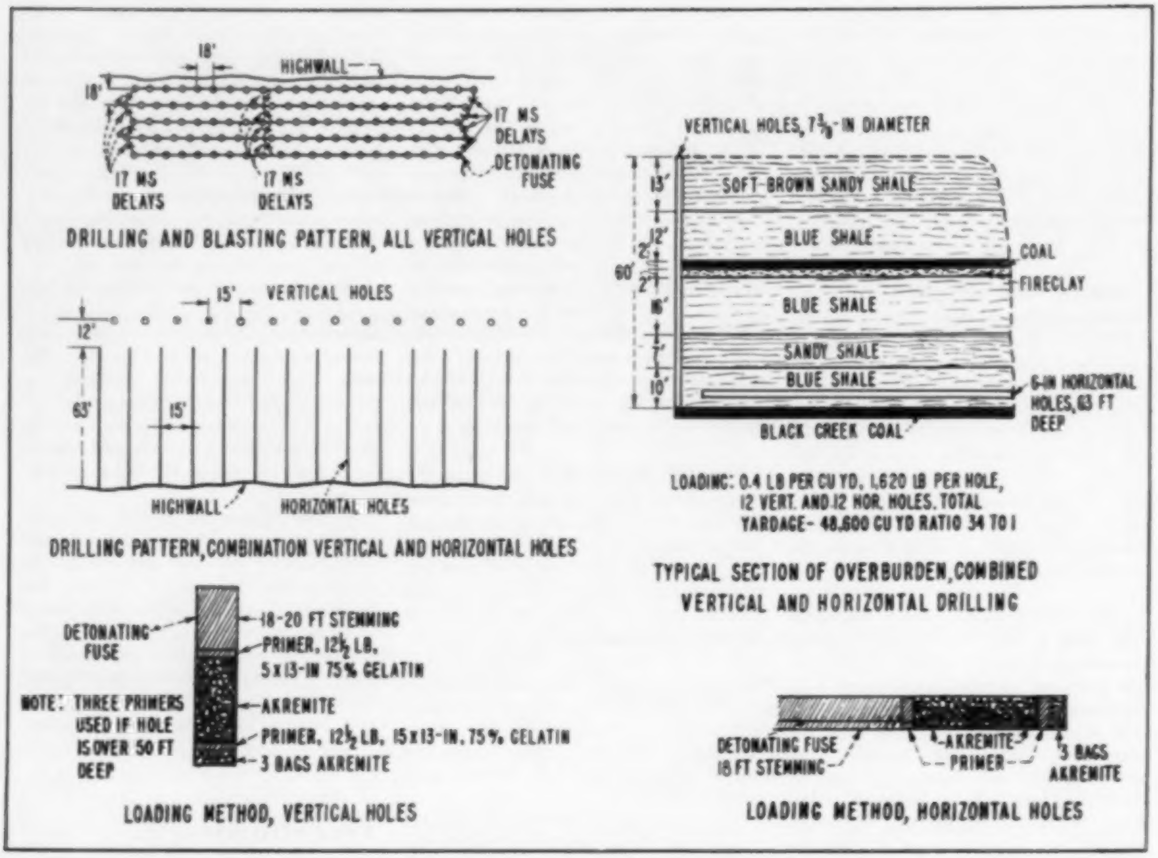
Use delay shooting where vibration is a problem.

Consider the advantages of shooting against a buffer where natural conditions permit.

Breaking overburden as fine as possible for easy digging while keeping drilling and blasting costs at reasonable values is the goal in overburden preparation. The cost of sinking more holes and using more explosives to get maximum fragmentation must be weighed carefully against the gain of easier digging with less wear and tear on the machine.

Drilling Rock

To keep pace with the larger, more efficient stripping units which are becom-



COMBINATION of horizontal and vertical holes charged with low-cost ammonium-nitrate-type explosive is effective in breaking up to 60 ft of hard shales. Charging ratio is 1 lb of explosive to 2½ cu yd of overburden.

ing more numerous as overburden gets thicker and tougher, high-capacity drills are coming into the picture more and more. The rotary dry-type machine continues to make gains for sinking vertical holes up to 12 in in diameter. Success of the early larger crawler-mounted vertical machines led to the development of smaller-lighter, more mobile and less expensive units for smaller operations. These smaller machines include both truck- and crawler-mounted units designed for operations producing less than 2,000 tpd.

LARGE-DIAMETER DRILLS—Large-diameter boreholes, which are possible with the rotary dry-type machines, offer the following advantages: an opportunity to use less dense, lower-cost blasting agents; ability to concentrate more explosives in the harder layers and thereby get better results with less explosives; and reduced drilling where hard cap rock or other hard layers must be broken.

Vertical rotary machines have drilled 1,000 ft of 10 3/8-in hole (*Coal Age*, March, 1953, p 80), and 1,200 ft of 6¾-in hole in a single shift (*Coal Age*, February, 1957, p 98).

When difficulty is experienced with the hole squeezing together in the portion drilled through clay or soil with a rotary vertical unit, it can be overcome by augering through the soft material and then changing to the regular roller bit. Although this requires two extra tool changes, the faster penetration of the soft material and the elimination of trouble resulting from squeezing will pay. At one Illinois operation this method of drilling resulted in a savings of $8,000 per year in bit cost.

At some mines auger stems are being used successfully with rotary dry-type machines to help bring the cuttings to the surface.

Another dry rotary unit in the crawler-mounted group cuts its own drill road and also has a built-in water-spray system to suppress fine drill dust (*Coal Age*, June, 1957, p 60).

VERTICAL AUGERING—Vertical augering machines have been improved to the point where they can drill a 9-in hole in coarse-grained sandstone to a depth of 100 ft. Operating through a multispeed transmission, drill rotation can be regulated according to the toughness of the rock. Up to 600 ft of hole per shift can be drilled with this machine.

At one Ohio mine two crews use auger-type machines to sink an average of 600 ft of hole each per shift in sandstone overburden (*Coal Age*, July, 1957, p 60).

A down-the-hole rotary percussion drill, working three shifts in an anthracite pit, sinks enough holes in hard rock to keep pace with 6- and 8-yd draglines. Water check valves between two of the drill rods prevent entry of water and dirt into the hammer if the compressed-air supply is interrupted in the drilling of wet holes (*Coal Age*, May, 1958, p 114).

HORIZONTAL AUGERING — The horizontal sidewall drill remains a favorite for special applications and where the cover is comparatively thin, or where tough rock lies close to the coal. In some cases they are used effectively for two-level drilling in thicker cover. Special

MECHANICAL TAMPING of blastholes conserves manpower, increases flexibility. Tamping rod is spooled on square reel.

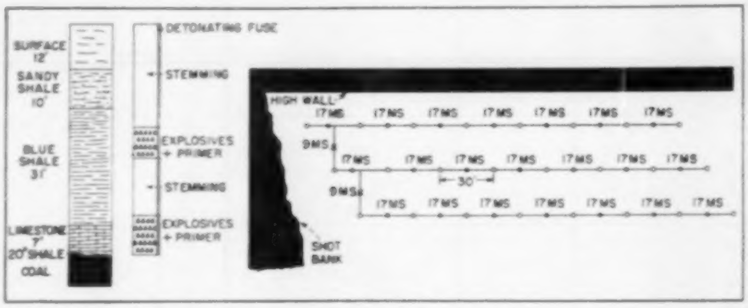
NEW ENTRY in drilling has features of vertical dry-type machines. Unit drills 9-in hole 48 ft deep with one drill stem.

adjustable-level hydraulically powered sidewall units can be used effectively to drill near a strata whose position over the coal varies up and down. They also have the advantage of easy leveling in an uneven pit.

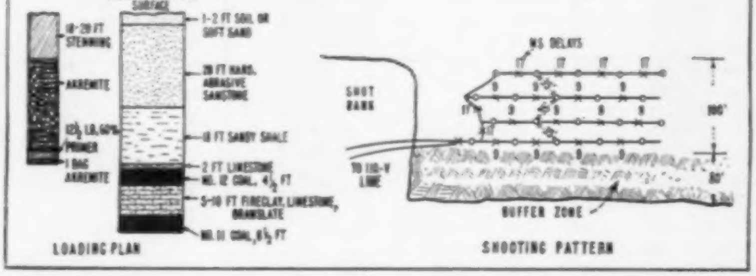
HORIZONTAL ROTARY DRILLING —To meet the need for more efficient equipment to drill hard rock fast, a horizontal rotary dry-type overburden drill now is available. One of these machines in service at an Indiana mine drills a 9-in hole 48 ft deep without adding drill sections. Penetration is 50 in per minute. Working one full and one part shift six days a week, it drills enough holes to prepare overburden for round-the-clock operation, seven days a week, of a 40-cu yd shovel. In the best single shift, 816 ft of 9-in hole was drilled by one man. Clean, smooth holes make possible loading of explosives with diameters only slightly less than the hole. Holes are reported to be straight and not to drift in the direction of rotation as auger-drilled holes do. Drill cuttings, as with vertical dry-type machines, make excellent stemming material (*Coal Age*, October, 1957, p 98).

SPECIAL DRILLS—Special units have been developed to drill thin layers of hard rock over the coal when the major portion of the overburden can be dug without blasting or to drill an interval between two seams. One four-unit jumbo machine mounted on a tractor drills 2-in holes on 6-ft centers and has capacity to keep pace with a 42-yd shovel that strips the main cover. (*Coal Age*, October, 1956, p 60).

A tough drilling problem in the Corbey area of England was solved by mounting a horizontal drill on a shovel boom so holes could be placed in sandstone 15 ft or more above the base of the overburden (*Coal Age*, January, 1958, p 130).



DECK LOADING is advantageous in overburden consisting of rocks with varying hardnesses. Millisecond delays increase the effectiveness of explosives.



BUFFER SHOOTING makes possible a uniform drilling pattern, eliminates large chunks sometimes produced when shooting against an open face.

Breaking Rock

Efficient overburden preparation is essentially a question of placing the right quantity of the right explosive in the right place. A continual study of the overburden plus constant checking of field results with explosives is necessary to make sure that drilling and blasting practices are the best possible for the given conditions.

Sometimes a particular type of rock can be broken best with a heavy charge in large-diameter holes spaced far apart. In other cases, smaller holes spaced closer together will provide better breakage. A combination of vertical and horizontal holes produces the best results at other times.

In selecting the right explosive for a job, engineers and operators must consider the physical characteristics of the bank, the drilling equipment available and the digging equipment to be used.

Method	Line No.	GEOLOGY: Coal Seam Thickness in Inches	Average Thickness of Overburden in Feet	Overburden Formation in Feet Top to Bottom	EXCAVATION: Width of Cut in Feet	Shovel Size in Cubic Yards	Production Av. Cu. Yds./Hr.	DRILLING DATA: Type of Drill	Drilling Speed Av. Feet per Hour	Bit Size and Type	Bit Life in Feet
HORIZONTAL DRILLING	1	41	40-45	Ss 3-4 / S 35-40	40	2½	300	AUGER	60	6" FINGERTIP	200
	2	41	40	S 40	40	2½	275	AUGER	60	6" FINGERTIP	200
	3	58	58	L 10 / Ss 40	60	5½ D	200	AUGER	45	8" CARBIDE	250
	4	58	58	L 10 / Ss 40	100	12 D	400	AUGER	45	8" CARBIDE	250
	5	18	27	S 27	42	2½	175	AUGER	80	6" THROW AWAY	200
	6	36	35	G 20-24 / Ss 12-15	72	5½ D	250	AUGER	60	6" FINGERTIP	25-80
	7	48	44	C 5-10 / Ss 20-25 / S 10-18	90	3½	150	AUGER	75	6" CARBIDE	——
	8	48	44	C 5-10 / Ss 20-25 / S 10-18	90	12½ D	410	AUGER	75	6" CARBIDE	——
	9	52	42	C & S 0-20 / Ss & L 10-20 / S 4-10	40	3½	175	AUGER	45	6"	——
	10	42	50	C 0-30 / Ss 10-25 / S 8-10	40	3½	200	AUGER	60	6½"	——
	11	52	45	C & S 10-30 / Ss 10-30 / S 4-8	45	3½	150	AUGER	50	6"	——
	12	60	35	S 15 / Ss 8 / S 22	60	6 D	400	AUGER	100	6" FINGERTIP	200
	13	60	55	C & S 25 / L 6 / Ss 6 / S 18	75	13 D	300	AUGER	30	6"-8" CARBIDE	1000
	14	36	20	C—Ss 3-4—Sl	60	2½-1⅝	——	AUGER	120	6"	——
	15	30	45	S	60	5½	330	AUGER	60	6¼"	500
	16	36	45	S—Ss	60	5½	300	AUGER	60	6¼"	500
	17	26	45	S—Ss 3—S	60	3	200	AUGER	60	6¼"	500
	18	18	40	Ss—S	50	7 D	400	AUGER	80	6¼"	1000
	19	36	45	S—Ss	60	5½	360	AUGER	60	6¼"	500
	20	42	50	Ss—S	60	5½	330	AUGER	60	6¼"	500
	21	27	30	Ss—S	40	3	150	AUGER	60	6¼"	300
	22	42	55	S—Sl	60	5½	330	AUGER	60	6¼"	500
	23	32	50	Sl	50	5½	330	AUGER	60	6¼"	500
VERTICAL DRILLING	24	36	35	C 5-8 / S 12-16 / Ss 12-14	60	4½ D	250	AUGER	50	6" FINGERTIP	35-70
	25	55	48	Ss 48	80	9 D	300	AUGER	110	6" CARBIDE	250
	26	55	48	Ss 48	80	10 D	300	ROTARY	80	6¼"	3000
	27	42	55	S 15 / Ss & S 12 / Cl 6" / Ss & S 22	50	15	600	AUGER	30	8" THROW AWAY	30
	28	42	55	S 15 / Ss & S 12 / Cl 6" / Ss & S 22	100	12 D	400	AUGER	30	8" THROW AWAY	30
	29	48	65	S 25 / Ss 40	65	5	375	AUGER	60	6" CARBIDE	300
	30	48	45	Ss 45	50	2½	——	AUGER	40	6" FINGERTIP	150
	31	52	35	Ss 35	40	3½	150	ROTARY	55	5⅝"	2700
	32	52	35	C & S 0-40 / Cl 1 Ss 12-18 / L 16-20 / S 4-8	60	12 D	385	ROTARY	50	6¼"	2000
	33	54	70	L 6 / Sl 2 / C 6 / Cl 2 / L 18-20	45	30	1000	ROTARY	40	8½"	7000
	34	54	70	L 6 / Sl 2 / C 6 / Cl 2 / L 18-20	45	17 D	450	ROTARY	40	8½"	7000
	35	42	32	C 5-8 / Ss 18-24 / S 0-5	45	18	800	ROTARY	120	6¼"	4500
	36	78	30	Ss 10 / L 8 / S 12	60	5½ D	200	ROTARY	60	6¼"	2000
	37	62	60	C 10 / L 2-6 / S 4 / L 6-10 S 5 / Ss 6-12 / Ss 8-12 / S 6-8	60	12 D	400	ROTARY	60	6¼"	1500
	38	52	50	Ss 20 / S 30	100	14 D	840	ROTARY	13	10⅝"	8000-10,000
	39	48	60	Ss—S	80	14 D	800	ROTARY	18	9"	8000-10,000
	40	27	45	S—Ss	60	5½	300	ROTARY	50	4⅜"	1200
	41	36	40	Ss—S	50	7 D	400	ROTARY	60	5⅝"	800
	42	42	50	Ss—S	60	5½	330	ROTARY	45	5⅝"	800
	43	29	40	Ss—S	50	5½	330	ROTARY	45	5⅝"	800
	44	54	40	Ss—S	40	3	130	ROTARY	60	5⅝"	650
	45	23	30	Sl—C—Sl	70	12 D	720	ROTARY	60	7⅞"	1400
	46	23	45	Sl—C—Sl	60	5½	330	ROTARY	60	5⅝"	800

After studying these carefully, they can chose a product to give maximum fragmentation. The drilling pattern will depend to a major extent on the foregoing factors.

HORIZONTAL LOADING — Shale overburden usually can be blasted successfully with a single row of horizontal holes if they are large enough to permit the proper loading ratio. A single row of holes should be drilled so that the resistance of the material above the holes will roughly equal the resistance of the material between. As banks increase in height, it becomes necessary to increase the size of the hole, since holes drilled close together tend to shear horizontally rather than exert force upward to produce the desired fragmentation. For deeper cover it is possible to use high and low horizontal holes or to combine horizontals with verticals. In the past vertical drilling was generally considered best in overburden over 50 ft thick. Two-level drilling was considered too costly and single-level inadequate. But with the advent of the new high-capacity horizontal rotary drytype drill a new era is in view for sidewall drilling and blasting.

Loading practices must be developed for individual pits. The method of distributing the charge in the hole can have an effect on blasting efficiency. With some types of rock, full-column loading produces the best results. With others, deck loading results in better fragmentation.

IMPACT BREAKING—At a western Kentucky mine recovering two 5-ft seams of coal separated by 11 ft of rock an unusual method of breaking the interval is used. The outer 25 ft of a 45-ft cut is broken with a 17-ton drop ball. The breaking medium actually is a steel billet 8 ft long, 60 in wide and 30 in thick. It is hoisted 50 ft into the air by a diesel-electric shovel converted to a crane and dropped on 6-ft centers. Cycle time is 45 sec. Excellent fragmentation is reported at a considerable saving over drilling and blasting.

DRILL PATTERN			BLASTING DATA		EXPLOSIVES RATIO		
HOLE DEPTH IN FEET	SPACING IN FEET	BURDEN IN FEET	METHOD OF DETONATION*	TYPE OF EXPLOSIVES	CU. YD. / LB. OF EXP.	LINE NO.	
36-40	10	42	P	40% Ammonia	2.8	1	HORIZONTAL DRILLING
36	12	40	P	40% Ammonia	2.5	2	
60	30	30	P	Blasting Agent + Primer	5.5	3	
60	30	30	P	Blasting Agent + Primer	5.5	4	
42	15	27	P	Blasting Agent + Primer	5.25	5	
72	15	35	P-SS	40% & LD Ammonia*	5.6	6	
90	17	44	P	LD Ammonia	5.6	7	
90	17	44	P	LD Ammonia	5.6	8	
45	15	40	P	40% & LD Ammonia	4.0	9	
60	12	40	P	40% Ammonia & Semigelatinous	2.7	10	
45	15	45	P	40% & LD Ammonia	4.5	11	
60	15	35	P-SS	LD Ammonia	2.6	12	
66	18	55	P	40% Ammonia	5.7	13	
60	15	20	P	50% Ammonia	1.0	14	
60	12	45	SS	LD Ammonia	8.0	15	
60	20	45	P	Blasting Agent + Primer	6.35	16	
60	16	45	P	LD Ammonia & Blasting Agent	4.5	17	
50	18	40	P	LD Ammonia	8.3	18	
60	15	30	P	LD Ammonia & Blasting Agent + Primer	5.0	19	
60	18	45	P	LD Ammonia & Blasting Agent + Primer	6.0	20	
60	20	30	P	50% Ammonia & Blasting Agent + Primer	5.3	21	
60	20	50	P	Blasting Agent + Primer	3.7	22	
60	18	50	P	Blasting Agent + Primer	6.6	23	
35	15	15	P-SS	Blasting Agent + Primer	2.5	24	VERTICAL DRILLING
48	15	15	SS	LD Ammonia	4.5	25	
48	15	15	SS	LD Ammonia	4.5	26	
55	32	25	P-SS	Blasting Agent + Primer	6.2	27	
55	25	25	P-SS	Blasting Agent + Primer	4.0	28	
65	15	27	P-MS Conn.	Blasting Agent + Primer	1.4	29	
45	10	10	P	LD Ammonia & Blasting Agent + Primer	2.5	30	
30	18	18	SS	Blasting Agent + Primer	3.0	31	
30	18	18	P-MS Conn.	LD Ammonia & Blasting Agent + Primer	2.5	32	
30	20	22	P-MS Conn.	Blasting Agent + Primer	3.0	33	
30	20	22	P-MS Conn.	Blasting Agent + Primer	3.0	34	
32	21	15	P-SS	LD Ammonia	4.0	35	
30	15	15	P-SS	40% & LD Ammonia	2.0	36	
60	15	15	P	LD Ammonia	1.5	37	
55	36	30	P	Blasting Agent + Primer	5.0	38	
60	27	30	P	Blasting Agent + Primer	3.0	39	
45	15	18	P	Blasting Agent + Primer	3.3	40	
35	18	18	P	LD Ammonia	3.6	41	
45	15	18	P	LD Ammonia & Blasting Agent + Primer	3.0	42	
40	18	18	P	LD Ammonia	3.2	43	
40	16	18	P	Blasting Agent + Primer	2.1	44	
28	21	72	P	Blasting Agent + Primer	4.1	45	
45	16	16	P	Blasting Agent + Primer	4.25	46	

BLASTING RECORDS—Good records should be kept for all blasts, including depth and spacing of holes, quantity and distribution of explosives per hole, type and thickness of overburden, feet of drilling, and cubic yards of material broken each day. When a satisfactory plan for shooting is worked out it should be adhered to until conditions change. The goal in blasting is to get maximum fragmentation at minimum cost and thereby make it possible for the stripping unit to move more material with less effort.

One company has developed an electric device that automatically records the depth of the blasthole as it is drilled. When a change of strata or a significant change in hardness occurs in the rock, it is reflected in a variation in drilling pressure. The drill operator notes depth on the indicator, as well as pressure, and records both in a log book. The record for each hole is given to the blaster to serve as a guide in charging the holes (*Coal Age*, May, 1955, p 122). The operator can look at the hole log, tell how tough the rock is and then determine how much explosives will have to be used to get the best results. Drill-pressure indicators also show changes in the hardness of the strata and thus provide additional data for judging placement and quantity of charges.

DELAY SHOOTING—Delay shooting usually will permit explosives to do a better job. At many mines milli-second delays have been used successfully to get better fragmentation and at the same time reduce concussion in the surrounding area. Reduction of vibration is especially important where stripping is being done near populated areas. The progressive relief possible with delays also permits the explosives to perform more efficiently.

As overburden becomes thicker, the problem of vibration and shock becomes greater because the thicker rock requires more explosives. In recent years, the MS-delay connector has become a valuable tool in reducing vibration—in many instances to about 25% of that with the usual shot.

The MS connector essentially is a piece of detonating fuse with a millisecond delay built into the center. Benefits from the connectors include setting off a greater number of holes per shot with less vibration, and elimination of the hazard involved in loading a cased hole where it is necessary to charge from the drilling machine through the casing and then pull the casing up over the shunted cap wires. During this operation there is always the hazard of stray currents or a short circuit that might ground through a damaged cap wire, setting off the charge. With detonating fuse, no cap is used until this operation is completed and the machine has moved away (*Coal Age*, June, 1951, p 86).

A further advantage includes a 15% speedup in the detonation of the explosive with a reduction in the requirements. Fragmentation is as good and probably better with the reduced charge. Digging into misfires is not likely to result in an accidental explosion since caps are not used.

While many applications have resulted from the use of detonating fuse and MS connectors, at least one serious disadvantage of the combination is the noise and concusssion caused by the detonation of the unconfined trunk line. When the shooting operation is close to populated areas, this condition presents a problem. At one mine where the elimination of noise is highly desirable, detonating fuse is used to fire the primers. Holes are shot in groups of 11, using a single instantaneous electric blasting cap and delay caps in series 1 through 10. Only a single shovelful of dirt is required at each hole to effectively cover the few inches of exposed detonating fuse and the blasting cap.

BLASTING MEDIUMS—Blasting mediums in use today include various types of high explosives; liquid oxygen; and newly developed lower-cost blasting agents, such as, Akremite (*Coal Age*, May, 1955, p 70).

Most of the explosive manufacturers

now are producing Akremite or similar blasting agents. New entries in this field include the following: (1) Nitro-carbonitrate which contains technical-grade ammonium nitrate instead of commercial grade. It is not cap-sensitive, and therefore a primer must be used to set it off. Speed is about 11,500 fps; (2) Unimite and (3) Methanite which contain technical-grade ammonium nitrate, coal dust and nitromethane. The nitromethane acts as a sensitizer for the ammonium nitrate and under certain conditions it is not necessary to use a primer. Speed is about 13,000 fps.

OIL-NITRATE MIXTURES—Another entry in the make-your-own group of blasting agents is made by mixing No. 2 fuel oil with prilled or grained ammonium nitrate in the ratio of 3 quarts of oil to 100 lb of nitrate. In some instances the oil is added in a mixing plant and put up in bags and only enough is mixed for one day's supply. Other companies add the oil in the field by pouring it over the ammonium nitrate immediately before the hole is charged. One company believes that the oil should have a chance to penetrate the nitrate and therefore lets the mixture season for a definite number of hours before using it. The mixing may be done in the shipping bags.

The latest development with ammonium nitrate and fuel oil mixtures is to use a heavier and more viscous oil having a higher heat content. The heavier oil is less volatile and does not soak into or through containers. Because of the increase in available energy, blasting results are improved. But to get the better results, it is necessary to use a mix rather than hand methods.

There is a trend toward using grained ammonium nitrate because it provides a blasting agent with 20% to 30% greater density and thus make possible greater concentration of the agent in drillholes. The velocity of the mixture also is 1,000 to 2,000 fps greater than when a lighter oil is used.

Some operators now are using a combination of grained ammonium nitrate for loading the bottom of holes and prilled nitrate for the top. The method of loading makes possible wider hole spacing and a corresponding saving in drilling.

NON-SENSITIVE PRIMERS—Nonnitroglycerine primers for use with make-your-own blasting agents are growing in favor. These primers are popular because they cannot be detonated if a shovel digs into a misfire. Danger to personnel and equipment from this hazard thus is eliminated. A popular unit combining safety and economy is a 5-lb primer packaged in a polyethylene bag.

Significant improvements in manufacturing techniques have resulted in lower prices for liquid-oxygen explosives. Having a speed of 17,000 fps, this explosive has been very useful in breaking high banks containing massive sandstone.

MECHANICAL TAMPING—The one operation in strip mining requiring a great deal of human effort—loading and tamping horizontal holes—has been converted to a mechanized operation. After undergoing several years of experimental use in Indiana, the first commercial model of load-tamp machine went into service in Illinois. With the aid of the load-tamp machine, one man in four days, single shift, does what it took two men five and six days to do. Greater flexibility in pit operations is an added benefit since blastholes now can be loaded after the seam is taken out to the highwall (*Coal Age*, September, 1957, p 88).

The operator's duties consist of placing the explosives and tamping bags in the collar of the hole. Using prefilled tamping bags, one man has loaded and tamped a maximum of 28 holes in a shift.

BLOW CHARGING—A new technique now going through the experimental stages is blow charging of blastholes. In this method the explosive is hauled to the blasting site in a hopper truck equipped with a high-pressure blower. It then is blown through a hose and packed firmly into the hole. Early results indicate that this method is very promising.

BUFFER SHOOTING—There are certain advantages to shooting against a buffer where vertical drilling is practiced. Large chunks of rock, sometimes produced when shooting against an open face are eliminated. The long toe that cannot be shot at all is eliminated. The drill never is required to work close to the highwall in an attempt to shoot a toe. A uniform pattern of drilling can be maintained because regardless of how crooked a pit is when first opened, adjustments can be made to produce a straight pit with a minimum of trouble.

Once a sufficient buffer is established to put the drill well ahead of the stripping machine, other benefits are possible. For example, in periods of dry weather the drill can be worked in areas of the highwall that would be very muddy in wet weather. And in wet weather the drill can be worked in ridges or high spots. If advance preparation of the highwall is needed for moving the drill, felled timber and brush can be pushed on to the buffer area and require no rehandling prior to final disposal.

The operation of the stripping unit can widen or narrow the pit to take full advantage of the machine in the spoil area available and without interfering with the drilling and shooting. Better slopes of the highwall can be made, thereby eliminating many slides that occur when there is a high, cracked overhang.

Stripping

Use draglines where flexibility and range are needed.

Use shovels in area stripping where seam conditions are uniform.

Consider heavy-duty bulldozers for stripping in conjunction with small or medium-size shovels.

Consider diesel-powered machines where frequent moves are made.

Study machine performance to detect wasteful motions or methods.

Keep cycle time to a minimum.

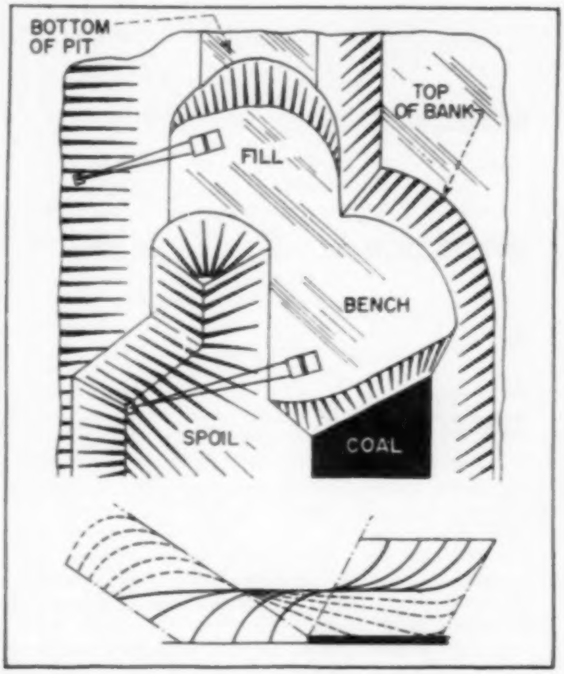
Use bulldozer or tractor shovel for pit cleanup behind stripper.

Keep digging teeth sharp.

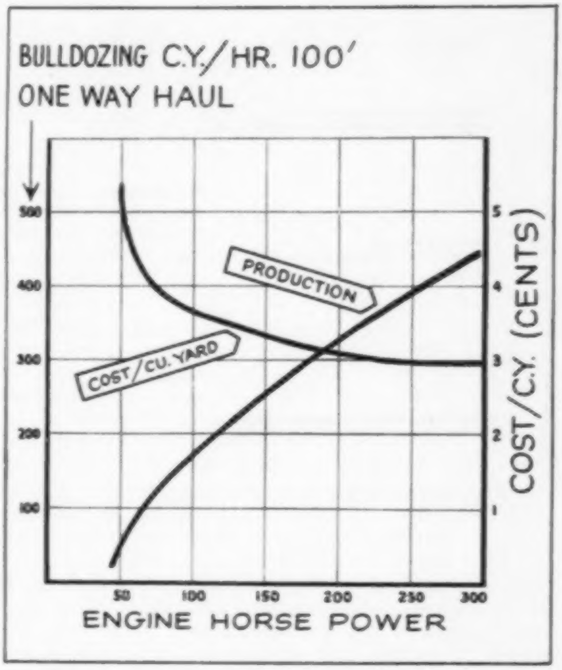
The goal with any stripping unit is to remove overburden as cheaply as possible. Assuming that the stripping machine is designed to work best in certain conditions, management has the responsibility of seeing that it and the operator perform as efficiently as possible. To get peak output any unit must work not only continuously but in a manner that will move more material. The more full-capacity bites that a machine makes in a shift, the higher will be the output.

There are a number of things that can be done to help boost capacity of a basic machine. These include using new lightweight, high-strength steel in the dipper to increase capacity without increasing weight; upgrading the skill of operators by training; and using auxiliary equipment on the highwall or spoil.

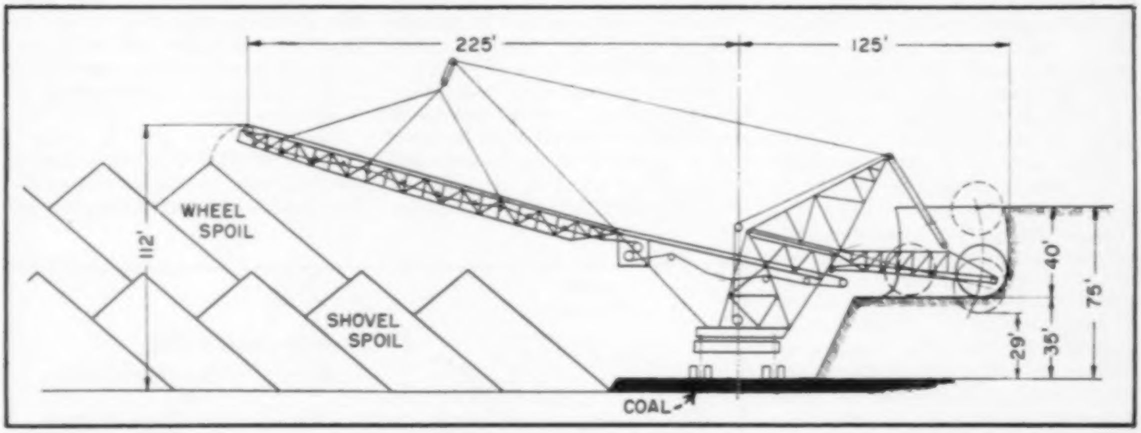
BOX-CUTTING—Opening a pit by box-cutting involves digging down to the coal and then working straight ahead to the limit of the property. By exercising care in opening a new strip pit along the property line in flat or gently rolling land it is possible to recover practically all of the coal in the tract. In some instances where a shovel or dragline is used to open a new tract along an adjoining property the first-cut spoil is placed on the surface next to the property line. Stripping then advances into the tract and the coal along the property line and under the first-cut spoil is left in place. Some operators do not consider it economically possible to rehandle spoil from the opening box cut and the



TANDEM PLAN includes one dragline with short boom, very large bucket; second has longer boom, smaller bucket.



MORE HORSEPOWER in engines of modern bulldozers has made possible more economical handling of material



WHEEL EXCAVATOR extends stripping limit by removing up to 40 ft of soft material and discharging it 350 ft away on spoil pile. Wheel removes upper portion and casts it well beyond edge of shovel spoil.

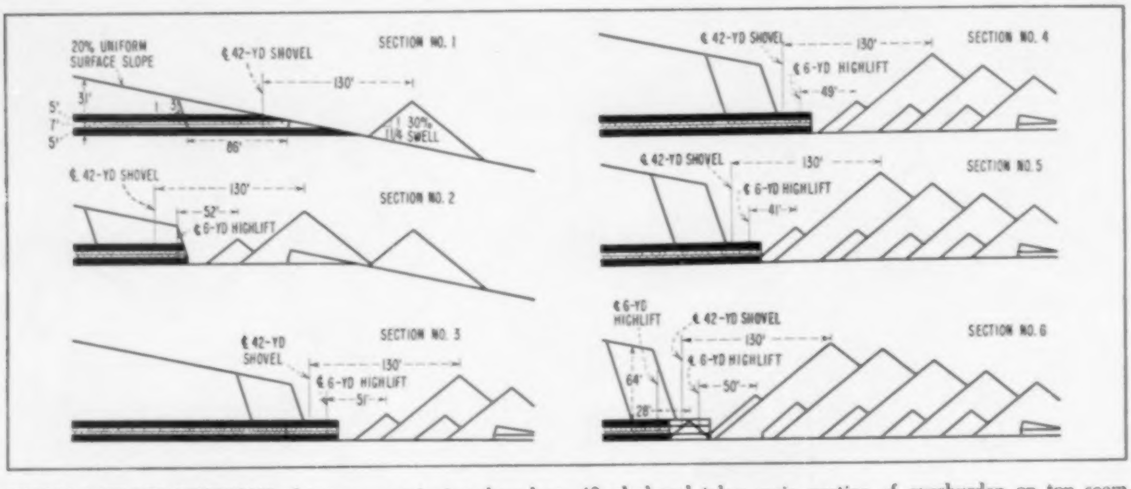
regular material over the coal. As a result, the strip of coal along the property is never recovered. If a strip of coal 75 ft wide, 4 ft thick and 3,000 ft long is left in place along the property line, the loss will be about 37,000 tons.

AUXILIARY MACHINES—The possibilty of using auxiliary earth-moving equipment, such as scrapers and bulldozers to move the spoil from the opening box cut should be investigated thoroughly. For example, it might be possible to start at the property line and cut down 10 to 20 ft of material with scrapers and spread it in a thin layer 4 to 5 ft thick over the surface where it can be easily handled in subsequent cuts. The scrapers could open the area by making a cut 100 to 200 ft wide along the property line. Exact width of cut can be laid out to fit into the overall plan for the regular stripping machine. It may be desirable for the auxiliary machine to cut down an area that is two or more times the width of the cut that will be taken by the shovel or dragline.

If the resulting pile is too high to be moved efficiently by the shovel or dragline when the second cut is made, a bulldozer can be teamed with it to level and spread the material in the spoil area. Or if the material is broken finely enough, it also might be possible to use scrapers effectively in the spoil area. The cost of rehandling the first-cut spoil should be weighed against the value of the coal left in place and the effect on the cost of handling overburden over the life of the mine.

BULLDOZER STRIPPING—As a result of more speed and power being built into today's bulldozers, they are being

be desirable to go to a higher bank. However, the available shovel or drag- a primary unit in removing the top layer of overburden. Thus the dragline burden Shovels are available in a wide range of designs and capacities to meet all



TYPICAL CROSS SECTIONS of two-seam stripping show how 42-yd shovel takes main portion of overburden on top seam and 6-yd highlift unit skims off thin layer over lower coal.

used more and more as stripping units. Working in pairs or in conjunction with other equipment, they are effective in moving overburden that normally requires little or no shooting.

Latest models available to the industry include single-engine units powered by engines delivering 230 hp and twin-engined models powered by two 218-hp diesels. Drawbar pull in the range of 60,000 lb or better is a feature of the new high-powered tractors. Modern tractors are available with either torque converters or direct drive.

Where stripping is assigned to bulldozers alone, a minimum of two should work together. For efficient material handling, an average of not more than 35 ft of cover should be moved and the terrain should be gently rolling or hilly to permit easier movement of overburden. Pushing should be 90 deg with the outcrop after the initial cut is made along the outcrop and the bulldozers should work together, one following the other and slightly overlapping the path of the leading unit to pick up side spillage.

After the pit is filled sufficiently, the dozers should start pushing to the main spoil area away from the highwall. As succeeding cuts are made and the highwall gets steeper, it will be necessary for the dozers to rehandle as much as 20% of the material. To establish the highwall, the bulldozers should cut parallel to the outcrop and dig down to the coal. If hard material is met, it should be drilled and shot fine enough so that the bulldozers can move it easily.

BULLDOZER-SHOVEL STRIPPING—Another possible combination for stripping up to 35 ft of softer material is the small shovel and the bulldozer. With this type of setup the bulldozer works across the outcrop and takes off 10 to 12 ft of loose material—sometimes up to 20 ft. (*Coal Age*, January, 1954, p 82). The shovel is used to remove the more solid material down to the top of the coal.

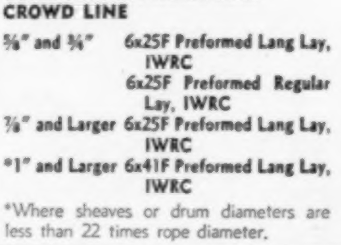
At another operation in Pennsylvania two big, powerful bulldozers are teamed with a diesel-powered 2-cu yd shovel and a 4-cu yd diesel dragline to move up to 60 ft of cover (*Coal Age*, March, 1957, p 82). Each dozer works with one of the strip machines in a separate pit, two shifts per day. The bulldozers not only cut down a portion of the bank but push a great deal of the material into the pit where the stripping units can handle it easier. They also push a large portion of the material in the spoil to a point beyond the range of the stripping units.

After a sufficient area of coal is uncovered, the shovel can double as a coal-loading unit while the bulldozer continues to remove the top layer of cover or performs utility or cleanup work. The shovel-bulldozer setup is not designed for high output but can be used effectively where cover is relatively soft and a large capital expenditure is not feasible.

SCRAPER STRIPPING—It is possible that conditions may change after a stripping unit has been purchased and it may

SHOVEL

Combination Hoist & Crowd



COMBINATION HOIST AND CROWD LINE

5/8" and 3/4"	6x25F Preformed Lang Lay, IWRC
	6x25F Preformed Regular Lay, IWRC
7/8" and Larger	6x25F Preformed Lang Lay, IWRC
*1" and Larger	6x41F Preformed Lang Lay, IWRC

*Where sheaves or drum diameters are less than 22 times rope diameter.

INWARD THRUST LINE

5/8" and 3/4"	6x25F Preformed Lang Lay, IWRC
	6x25F Preformed Regular Lay, IWRC
7/8"	6x25F Preformed Lang Lay, IWRC
1" and Larger	6x41F Preformed Lang Lay, IWRC

DIPPER LATCH LINE

	6x36G Preformed Regular Lay, Fiber Core
	8x19E Preformed Regular Lay, Fiber Core
	7x19 Preformed Aircraft Cord sizes under 1/4"

BOOM HOIST LINE

	6x25F Preformed Regular Lay, IWRC

WHAT WIRE ROPES are recommended

be desirable to go to a higher bank. However, the available shovel or dragline may not be able to handle the overburden in one pass. Consequently, rehandling or two passes are needed. Or the unforeseen problem of a shortage of spoil area may develop and partial haulage may be necessary. Under these conditions the high-speed rubber-tired tractor-scraper has gained acceptance as an efficient auxiliary machine to move the top portion. Once loaded, the unit can haul spoil several hundred feet at little added cost. If the overburden is compacted, it is good practice to supplement the scraper units with a rooter that can be taken over the area ahead of the scrapers to break up the ground.

Tractor-scraper units can be used to make an opening cut and working bench for a dragline (*Coal Age*, June, 1949, p 94), or remove up to 35 ft of overburden (*Coal Age*, August, 1953, p 74). The number of tractor-scrapers needed for the job depends on how much of the total cover can be moved by the scraper and how much overburden must be moved to uncover the coal needed each day. For example, five tractor-scraper units aided by a rooter have removed 30 to 35 ft of cover at an operation working to a 75-ft highwall and producing 1,700 tpd of strip coal. Shovels remove the lower portion of the overburden. A very worthwhile advantage of the scaper method of handling spoil is that little extra work is necessary where backfilling and leveling are required.

In some present day deep anthracite pits where available draglines cannot handle overburden in one pass, the high-speed scraper has been well accepted as a primary unit in removing the top layer of overburden. Thus the dragline burden is eased. Some advocates say that it costs less to move overburden with scrapers than with a shovel and trucks.

A push-loaded scraper will load faster and will carry greater payloads because the load is heaped better and packed tighter. To get the most from scrapers, the loading area should be planned so that the units load on a down grade; haul roads should be well maintained; and the dumping area kept in good condition so the load can be released while traveling at a fair rate of speed.

Good preventive maintenance practices to follow in scraper operation include keeping good cutting edges on the scraper at all times; and holding the apron at proper height while loading to avoid damage or distortion. A mis-shaped apron permits load leakage on to the haul road with possible resultant tire damage. A light channel welded across the top of the scraper front end will prevent the sides from bulging and will not hinder loading.

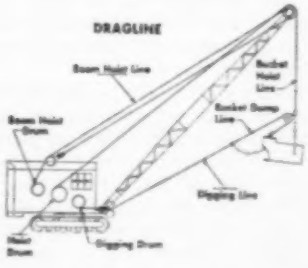
The development of the hydraulically operated ripper mounted on a large bulldozer has increased the range of the scraper. The shales and soft rock that previously resisted loading by scrapers or ripping with old-type rippers or rooter are now successfully loosened. In one pass the hydraulic unit with three arms spaced at 53 in loosens a total width of 9 ft to a depth of 12 in. The cost of this work, depending on hardness and stratification of the rock, should not exceed 2c per cu yd.

SHOVELS AND DRAGLINES — Shovels are available in a wide range of designs and capacities to meet all stripping conditions. For example, a 3-cu yd shovel with a 28-ft boom and 20-ft dipper handle can cut to a 32-ft height. A 45-yd shovel with a 120 ft boom and 79-ft dipper handle can cut to a height of 107 ft. The 60-yd shovel which went into service in 1956 has a 150-ft boom and can pile spoil 97 ft high. The 70-yd shovel which began stripping in 1957 has a 140-ft boom and a maximum dumping height of 96 ft 6 in.

Draglines also are available in a wide range of sizes to meet varying conditions. A 2¾-yd dragline with a 110-ft boom can dig to a depth of 58 ft and spoil to height of 49 ft above the bottom of the bench on which it is working. A 35-yd unit with a 220-ft boom can dig to a depth of 94 ft and pile spoil 98 ft high above the tub. In between these sizes are a host of machines that can handle nearly any assignment.

Big shovels in the 33- to 70-yd range usually work to a maximum of 70 or 80 ft of cover. Removal of overburden between 9 and 50 ft thick by a 45-yd shovel costs about 45% of what it would cost to do the same job with an 8-yd shovel; in overburden between 9 to 90 ft, about 77% of the cost with an 8-yd shovel and in overburden between 50 and 80 ft, about 25% more than an 8-yd shovel working in a bank 50 ft high. Big shovels also recover coal that would be left by smaller shovels or would have to be auger or deep mined. However, it must be remembered that the area to be stripped must contain enough coal to warrant the capital expenditure for a big shovel.

Flat coal seams and steep slopes cause overburden thickness to increase rapidly as successive cuts advance into the hillside. To meet these difficult conditions, the large walking dragline is most useful because of its long dumping range. The stripping life is increased in proportion to the dumping range of the dragline, and maneuverability of the unit is advantageous in working sharp angles and inside curves. The disadvantage is that it must have a suitable base and this is sometimes difficult to provide in rocky overburden. This factor must be considered in choosing between a dragline and shovel.



DIGGING LINE (LOAD LINE)

5/8" and 3/4"	6x25F Preformed Lang Lay, IWRC
	6x25F Preformed Regular Lay, IWRC
7/8" to 1½"	6x21F Preformed Lang Lay, IWRC
1⅝" and Larger	6x25F Preformed Lang Lay, IWRC

BUCKET HOIST LINE

5/8" and 3/4"	6x25F Preformed Lang Lay, IWRC
	6x25F Preformed Regular Lay, IWRC
7/8" to 1⅛"	6x25F Preformed Lang Lay, IWRC
1¼" and Larger	6x41F Preformed Lang Lay, IWRC

BUCKET DUMP LINE

	6x25F Preformed Lang Lay, IWRC
	6x25F Preformed Regular Lay, IWRC

BOOM HOIST LINE

	6x25F Preformed Regular Lay, IWRC

Courtesy Macwhyte Co.

for use on draglines and shovels.

Operating Stripping Units

To get the maximum return from the investment, the stripping machine must be kept working as much as possible, and with no lost motion. To assure the best from shovels or draglines, some companies have installed recorders to indicate work time, angle of swing and the number of swings per shift. These records are studied to detect recurring delays.

Useful Capacity and Performance Data for Draglines

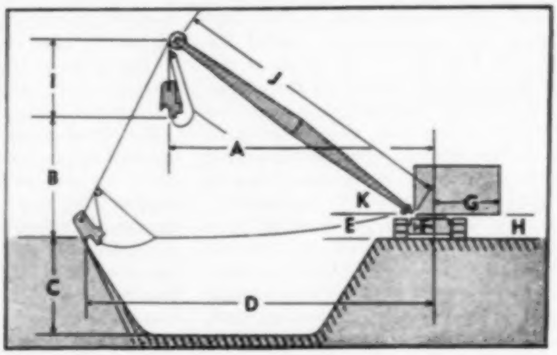
(All dimensions in feet unless otherwise specified)

Bucket size, cu yd	3	3½	3½	4	4	4½	4½	5	6	7	8
J. Boom length	110	110	100	100	90	90	80	100	90	80	80
K. Boom angle, deg	37	41	34	43	36	41	38	37	39	41	41
A. Dumping radius	95	90	90	80	80	75	70	90	80	70	70
B. Dumping height	56	62	45	56	41	47	38	42	39	34	35
C. Digging depth	51	45	61	50	39	33	43	41	34	28	28
D-A. Bucket throw	20–30	20–30	15–25	15–25	15–25	15–25	10–20	15–25	15–25	10–20	10–20
I. Bucket dimension	16	16	16	18	18	18	18	20	20	21	21
Bucket size, cu yd	**10**	**12**	**13**	**20**	**23**	**25**	**26**	**30**	**30**	**30**	**35**
J. Boom length	200	185	175	280	235	260	235	240	235	200	220
K. Boom angle, deg	31	32	33	35	30	35	36	35	43½	30	35
A. Dumping radius	190	175	165	250	222	234	209	218	190	191	201
B. Dumping height	81	73	70	138	98	124	116	110	136	76	98
C. Digging depth	97	87	80	120	140	111	145	102	120	120	94
D-A. Bucket throw	30–50	30–45	30–45	50–70	—	45–65	—	40–60	—	—	35–55
I. Bucket dimension	26	29	29	28	—	31	—	34	—	—	35

Explanation of Tables

Source of data. This is a revision of a table which was based in part on data obtained from the Power Crane and Shovel Association, supplemented by data from manufacturers' bulletins.

Note: The above data show what representative types of draglines can do. For specific earth-moving problems, the reader is advised to refer to the manufacturers listed under draglines and power shovels in the Buyers' Guide of this issue. Bulletins available will give much useful information. (From Eng & Mng Journal)



Refer to this drawing for symbols shown in table.

Another important factor in good machine operation is reducing cycle time to a minimum. The time consumed in loading, swinging, dumping and returning for a new load must be kept to a minimum. Proper planning of spoil areas goes a long way toward keeping the swing arc as short as possible as the machine rotates between pit and spoil area.

The key to fast loading is a well-prepared bank and the finer the material the faster it can be loaded. But it must be remembered that there is an economic limit to spending money for explosives to break the rock into fine pieces. Each operation must be examined carefully before a decision is made as to how much fragmentation is economically feasible.

BOOSTING DRAGLINE EFFICIENCY—Machine output can be maintained at a high level if the operator handles it in a manner to get the best digging efficiency with minimum power consumption. It is sound practice to analyze the work of the dragline to determine if the operator is getting the most out of the machine.

Proper working of the digging face offers the best opportunity for achieving maximum production from a dragline with a minimum of power consumption and wear and tear on the machine. Slicing material off in layers will give more output than working in trenches. However, a "key" or trench cut along the highwall line frequently will ease the rest of the work. The dragline bucket should be loaded as quickly and hoisted as nearly vertically as possible to keep power consumption at a minimum. Poor operation, such as digging on a slope near the machine and lifting the loaded bucket approximately 45 deg with the vertical may consume up to 42% more power.

Quick loading and immediate hoisting will move the most yardage. By keeping the digger area under the boom, dividends will be reaped in greater output. The bucket should be filled while traveling two or three bucket lengths and then hoisted immediately. Every effort should be made to get a full bucket in the short travel but if it is not completely filled, it is best to lift and swing the load. By hoisting the bucket as soon as it is loaded, dirt pileup in front of the machine will be avoided and the danger of drag rope wear will be eliminated.

Sidepulling with the boom over-heats and wears swing clutches, puts unnecessary wear on the flanges of the boom-point sheave and may result in a twisted boom. This should be avoided to keep maintenance down.

BUCKET MAINTENANCE—Proper handling on the job, coupled with good maintenance procedures, will keep bucket maintenance to a minimum. Among the bad operating practices to avoid are striking the bucket against a solid object to loosen sticking material; dropping the bucket, especially with the teeth down; slapping the bucket against the boom while hoisting; and pulling the drag-bail socket into the fairlead.

Bucket teeth take a beating and must be kept sharp for good digging. Spare sets of teeth should be kept on hand for frequent changing so that worn units can be built up with hard-surfacing materials. Under no conditions should teeth be permitted to become badly worn.

Small cracks develop in the bucket from time to time as a result of accidental abuse. These weak spots should be repaired as quickly as possible to prevent big repair bills later. Many companies find it profitable to buy a minimum of two buckets for each dragline so that bucket maintenance can be done on the regular work shift without reducing dragline output. When repairs are needed the bucket is changed on the off-shift, or with a minimum of delay if the dragline works around the clock. Two buckets kept in good condition and used alternately will last longer than

Useful Capacity and Performance Data for Power Shovels

(All dimensions in feet unless otherwise specified)

Dipper capacity, cu yd	1½	1½	2½	2½	3	3	3½	4	4	4½	5-6	6
Special type*	—	HD	HD	HL	—	—	—	—	HL	—	—	—
X. Boom angle, deg	50	60	50	50	45	60	50	45	50	45	45	45
B. Boom length	23	22	26	42	29	27	29	33	67	32	35	35
C. Dipper handle length	18	17	20	32	20	19	19	22	50	21	23	23
D. Dumping height, max	21	24	24	38	20	28	23	24	60	21	22	24
E. Cutting radius, max height	26	21	29	50	34	38	33	37	70	39	44	45
G. Cutting height, max	30	33	34	49	30	40	34	35	73	32	34	37
J. Cutting radius, max	32	30	37	55	38	38	38	44	82	44	47	49
I. Cutting depth below grade	7	6	8	14	8	8	8	10	4	8	8	8
H. Radius of cleanup	21	19	23	31	23	26	24	29	50	27	28	30
Maker**	LS	K	K	BL	M	LS	PH	BL	BL	PH	PH	PH
Model No.	K360	605	1005	1201	101M	K608	1055E	1601	2400	1400	1500	1600
Dipper capacity, cu yd	**6**	**7**	**7**	**8**	**8**	**9**	**10**	**18**	**40**	**45**	**45**	**70**
Special type*	—	—	LR	—	—	IR	—	—	SS	—	SS	—
X. Boom angle, deg	45	50	45	45	45	45	45	45	45	49	45	49
B. Boom length	38	38	70	39	43	55	44	105	113	120	113	140
C. Dipper handle length	23	23	40	23	25	32	27	69	70	79	64	83
D. Dumping height, max	24	25	52	27	26	39	27	73	76	80	71	96
E. Cutting radius, max height	46	44	74	48	49	60	52	112	107	120	106	132
G. Cutting height, max	37	37	65	41	40	54	42	92	104	107	100	127
J. Cutting radius, max	49	48	79	53	54	67	57	120	132	131	127	148
I. Cutting depth below grade	10	9	8	8	11	5	13	—	—	—	—	—
H. Radius of cleanup	33	30	45	35	35	43	38	69	76	71	76	—
Maker**	BE	M	PH	PH	M	PH	M	—	BE	—	BE	M
Model No.	150B	151M	1855	1800	181M	1855	191M	—	1050B	—	1050B	5760

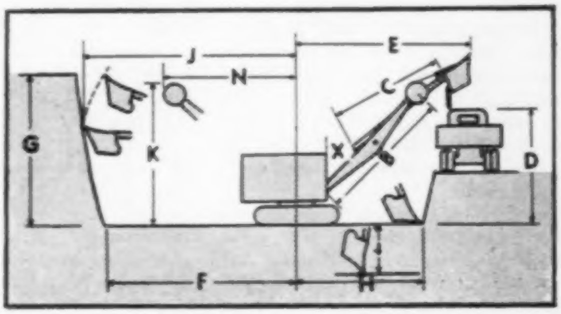
Explanation of Tables

Note: For help with a specific earth-moving problem, consult the manufacturers listed under Power Shovels in the Buyers' Guide section of this issue. Bulletins supplied by shovel manufacturers present complete data including performance ranges for boom angles varying from 40 to 60 deg.

***Key to symbols**—HD, Heavy Duty; HL, High Lift; IR, Intermediate Range; LR, Long Range; SS, Stripping Shovel.

****Key to symbols**—BL, Baldwin-Lima-Hamilton; K, Koehring; LS, Link-Belt Speeder; M, Marion; NW, Northwest; PH, Harnischfeger; TL, Thew-Lorain; BE, Bucyrus Erie.

Note: The above data show what representative types of shovels can do. It is based in part on a table prepared by the Power Crane and Shovel Association, and supplemented with manufacturer's data, supplied for Eng & Mng Journal.



Refer to this drawing for symbols in table above.

buckets bought one at a time and used continually until worn out.

SHOVEL OPERATION – As with dragline loading, the bank should be removed in slices in shovel work. The thickness of the slice should be such that the dipper will be filled as it reaches the top of the bank. It is usually good practice to dig the top half of a high bank first. This method keeps sloughing into the pit to a minimum and avoids lowering of the dipper to the bottom each cycle. Consequently, cycle time is speeded up and output is increased.

Load indicators also are gaining in favor to show the operator when the dipper is fully loaded and ready to be hoisted (*Coal Age*, October, 1953, p 80). The operator can be trained to hoist and swing as soon as a full load is indicated on a meter in his cab rather than relying on personal judgment. An indirect benefit from load indicators is less overloading and therefore fewer breakdowns.

Short moves should be made to maintain an efficient digging position. Digging beyond the boom point should be kept to a minimum. When working with too much reach, too much time is lost crowding and retracting. Sweeping the dipper back and forth to level off spoil causes side strains and wear on the boom, dipper stick and dipper.

Pit Cleaning

Pit cleanup should not be done at the expense of reducing the operating efficiency of the stripping unit. Remember that the goal in stripping is to keep the stripping unit working at full capacity. A great deal of valuable time can be lost by attempting to clean up widely scattered boulders that can be cleared from the coal by an auxiliary unit, such as a bulldozer. The money spent on an auxiliary dozer and operator in most cases will be more than repaid by an increase in output of the stripping unit and a corresponding boost in coal production.

It usually is more economical to have the stripping unit scale down loose material on the highwall as stripping is done than to trim the wall later with the coal-loading unit. In some cases, particularly where the cover is thick, it may be impossible for the coal shovel to reach loose material and therefore some coal will have to be bypassed until the next cut is uncovered. This makes a ragged pit and may result in some coal being lost under the spoil bank.

Stripping Thick Cover

Where extra thick cover is constantly present, the big dragline is the most popular machine. However, the success-

ful application of the 60- and 70-yd units shows that shovels can not be counted out in the thicker cover. Since going into service in February of 1956, the 60-yd giant's performance has been very satisfactory and the 70-yd machine already is proving its value. Output of the 60-yd machine has been at a rate well over 2,000,000 cu yd per month while working to 80-ft banks

TANDEM STRIPPING—There is no fixed rule regarding equipment application and many combinations of machines are doing yeoman duty. For example, a shovel may be teamed with a dragline in a tandem operation. In this type of setup, the drag works ahead, taking the upper section of the overburden and leaving the remainder for the shovel. The percentage of material to be handled by each unit depends on the capacity of each and the stripping conditions.

Various other combinations are being used in tandem operations. Where there is a fairly thick layer of soft material at the surface, tractor-scrapers and bulldozers can work on the highwall and cut down a sizable portion of the overburden. Auxiliary equipment also can be used effectively on the spoil pile to permit stripping units to work to higher banks. The choice of equipment depends upon the job and the quantity of material to be rehandled. Where auxiliary units work on the spoil bank, they frequently do a great deal of leveling so that final reclamation or backfilling is not too costly.

If only one machine is desired for stripping under consistently thick cover, the dragline usually gets the nod. Improved electrical controls and bigger motors have made it possible for the drags to work to higher banks and move more cover per hour. The result is more material moved at not greater cost than when working to lower banks. Where shovels would be working at extreme range or working limit, rehandling materials, or working in two lifts the dragline definitely offers advantages.

HAULING SPOIL—Whenever possible, thick cover should be removed by casting. However, there are limiting factors, such as, spoil area available and range of the stripping unit. If the coal seam lies flat, is of average thickness and brings only an average sales price, it usually is not profitable to haul spoil. But if the coal is steeply pitching or is extra thick and the sales price is high enough, spoil haulage is feasible as a means of increasing the stripping range. Spoil haulage is most common in the anthracite area and is being carried on to a lesser degree in the bituminous.

Rugged high-powered end-dump trucks lead in spoil haulage, with tractor-scrapers and rock wagons moving a respectable portion of the material. In many cases, spoil is hauled to worked out sections of the pit, while in others such as hillside stripping, it is hauled to ravines or below the outcrop. The wheel excavator with its stacker belt also may be classed as a spoil hauler as well as stripper since it carries spoil beyond the limit of the ordinary stripping unit.

THE WHEEL EXCAVATOR — The wheel excavator has been developed for use in the United States to cut the cost of moving material in 50- to 85-ft highwalls. The three objectives in using the machine are: (1) to handle overburden up to 85 ft thick, and place the spoil far enough away to avoid slides; (2) to cut the cost per cubic yard below that possible with conventional machines of equal size and capacity; and (3) to leave any overburden not moved by the machine so low in height that capacity of the accompanying shovel or dragline will be increased.

WHEEL EXPERIENCE — Operating experience with American wheel excavators show that they can move 1,700 cu yd of overburden per hour and spoil it a maximum distance of 388 ft from the digging point (*Coal Age*, March, 1955, p 58). Power costs per yard are the same as a large shovel and are considerably less than draglines.

A significant saving in drilling and blasting cost is possible with the wheel excavator where it can be used. For example, one Illinois operator was able to shorten blastholes by 30 to 40% while eliminating the problems of hole squeezing and casing through sand. At the same time bit cost was reduced considerably.

At another wheel operation, a wheel strips and spoils 10,000 cu yd per shift, moving 25-30 ft and leaving 30-35 ft for a 33-yd shovel (*Coal Age*, July, 1956, p 60). Cuts taken by both machines are 45 ft wide, but the wheel-excavator cut is offset from 10 to 15 ft from the shovel cut to provide a bench that prevents spillage of the softer top material onto the uncovered coal where the shovel would have to re-handle it.

The narrow bench left by the wheel provides another advantage since the shovel can work to a nearly vertical face on the lower bench, instead of having to shape a sloping highwall to prevent sloughing of the softer top material.

Two-Seam Stripping

In some instances, both in anthracite and bituminous, two seams fairly close together can be mined profitably where one alone would not be a profitable venture. Or, recovery of a thinner second seam, since overburden removal is necessary to get at the main seam anyhow, provides a low-cost additional source of tonnage. The method of mining and equipment used for multiple-seam stripping depends upon the dip and thickness of the beds; the lay of the land; and the type of rock above and between the seams.

PITCHING SEAMS — In anthracite mining, multiple seam stripping usually 's on the pitch. Overburden may be moved by any of the standard types of stripping equipment, including draglines, shovels and draglines, or shovels alone. Spoil haulage is common practice.

FLAT SEAMS—Where there are flat or nearly flat seams, overburden can be moved by a specially designed shovel (*Coal Age*, August, 1954, p 64); two draglines plus an auxiliary shovel (*Coal Age*, July, 1955, p 56); or a shovel and dragline (*Coal Age*, January, 1953, p 84). The choice of equipment in each case was made to get the best results under the conditions.

The specially designed shovel strips two seams simultaneously from one position in gently rolling country. Both seams are thin and are separated by 16½ ft of rock. Working on the lower seam, the shovel uncovers a 50-ft strip on each level while working to banks up to 60 ft above the upper seam.

The two draglines and auxiliary shovel are used in flexible setup in gently rolling country to mine two seams separated by 3 to 10 ft of limestone. Where banks range between 50 to 70 ft in thickness, the two draglines work in tandem, and where cover is thinner they work separately. The limestone interval between the two seams is drilled with percussion units and the broken material is cast to the spoil area by the coal shovel on the off shift.

The shovel and dragline were teamed to mine two seams separated by about 40 ft of rock in hilly country. Operating procedure is to remove the lower seam back to the outcrop of the top seam, using the shovel to make a working bench for the dragline which completes the cut. Next the shovel removes part of the cover and makes a bench on the upper seam for the dragline, which strips to a 40-ft bank. After this coal is removed, augering is done to complete mining in the upper seam. The next step is to recover the lower seam, leaving a 90-ft highwall. Augering to a depth of 175 ft in the lower seam is the final stage in mining at this property.

One of the newest two-seam stripping operations is the River Queen mine where a 55-yd shovel chews up overburden at the rate of 100,000 cu yd in 24 hr. Designed originally as a 70-yd unit,

the shovel was cut to 55 yd so that a longer handle could be used for the two-seam stripping job (*Coal Age*, June 1957, p 84).

Improving Performance

Time studies can be used effectively to improve machine performance and thereby cut costs. A careful study or group of studies often can result in getting more useful work per hour and boosting the actual working time of the machine. Hence machine capacity is increased.

INDUSTRIAL ENGINEERING – Industrial engineering techniques are being applied more and more to help mine management increase operating efficiency. And this practice is becoming more widespread in strip mining. A time study method designed for stripping shovels can be very simple, but the benefits can be large.

To get the most from a shovel time study, conditions under which the unit works must be studied carefully. Shovel performance can be affected directly or indirectly by width of coal pit or strip pit, width of haulage berm, water in the pit, haulage units and depth of overburden.

The type of overburden and how easily it can be dug is especially important. A series of time studies and a careful analysis of the results will show when the most economical point of overburden preparation has been reached.

RECORDER STUDIES–Time studies for shovels can be divided into two types. The simplest is a daily record of how many swings the machine makes and the length, in degrees of arc, of each swing. This information is obtained automatically by mounting a recording device, sometimes called a swing recorder, on the shovel. This device has a spring clock which pulls a roll of graph paper past a moving recording needle. The recording needle is synchronized with the movement of the machines swing gears and records each swing on the roll of graph paper.

This type of study indicates when no useful work is being done—a straight line appears on the recorder roll. To provide management with information on these delays, shovel operators should be given daily delay forms on which to check off the cause. If these forms are designed properly, all the operator need do is place an X in the proper place to pinpoint the cause of the delay.

From the recorder sheet and the operator's delay sheet, engineers can make a complete report of how much time was spent digging, how much time was lost in delays and the number of swings.

DETAILED STUDIES – More detailed time studies involve going over each motion of a shovel with a fine-tooth comb. The goal with this type of study is to control or improve such elements as swing, crowd, hoist to spoil area and filling the bucket, and then to blend them into an efficient cycle. Once a standard cycle is set up, continuing studies can help maintain the standard.

Better bank preparation, changes in digging techniques, redesign of various parts of the machine, changes in dipper and tooth design or revision of electrical equipment are some of the major items that may be desired as a result of analyzing time studies.

Augering

Since the highwall auger was introduced to the industry, it has grown to the point where it is producing in the neighborhood of 10,000,000 tons a year. When teamed with stripping equipment, such coal-recovery drills have permitted stripping to be done to higher banks. The combined cost of auger coal and strip coal from the higher bank can be made to equal or better the cost when stripping alone is done under thinner cover.

Coal produced by augering usually is dry, clean and has a good proportion of lump sizes. However the proportion of lump usually decreases as the augering depth increases. Where the seam is overlaid by a layer of high-ash coal, selective mining can be practiced and clean coal produced without preparation.

PREPARING FOR AUGERING – If augering is to be done as part of the stripping operation, it is wise to make preparation as stripping progresses. Care should be taken in blasting so that the highwall will be left unshattered and stable. A highwall slide can endanger the lives of men or result in serious damage to the auger in addition to causing a loss in production. A clean well-drained pit of suitable width for auger operation should be left as stripping progresses. It is much more economical to anticipate the use of the auger and make the necessary preparations as part of stripping than to do it later. It also is desirable to auger as soon as possible after stripping is completed and while the highwall is in the best condition. If there is coal remaining beyond the augering limit, solid blocks of coal should be left to permit access for future deep mining. The size of block to be left depends upon the thickness and type of cover, and the thickness and the strength of the coal.

AUGERING METHODS – Augering usually is done by drilling single holes to the desired depth with a unit that takes nearly the full seam height. However, for seams more than 5½ to 6 ft thick, it is best to use a smaller auger and double drill, preferably overlapping the bottom hole into the top. Staggering top and bottom holes is another method. The depth to which augering is carried out depends to a great extent on the coal thickness, whether the seams roll or are flat, and whether they are strong enough to stand after penetration and not foul the auger. Distance between holes also depends on the strength of the coal and the overlying rock.

Augers are available in diameters ranging from 16 to 52 in, and are capable of producing as much as 800 tons of coal per shift. To increase flexibility in operation, augers are available with conveyors that permit coal to be discharged on either side of the unit.

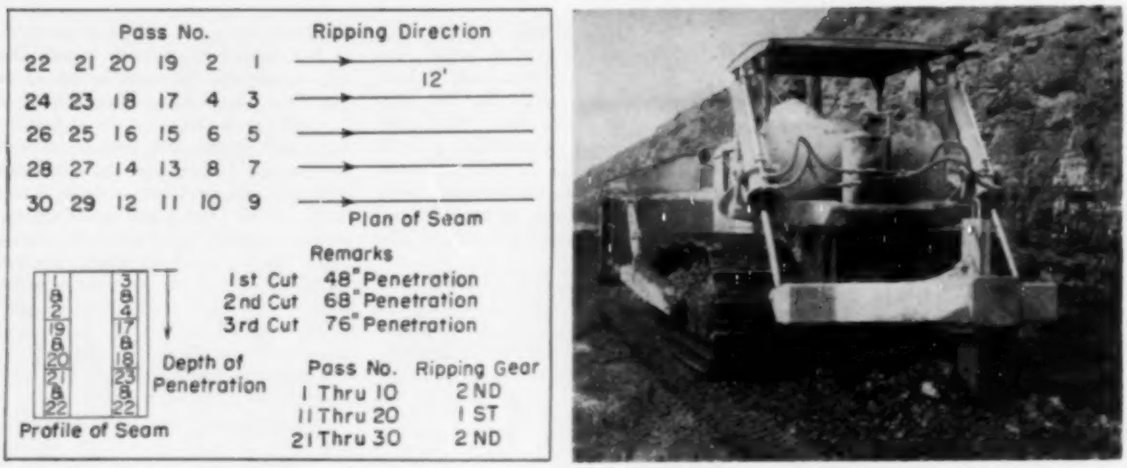
A three- or four-man crew usually handles all the work involved in the augering an is supplemented by a group of truck drivers.

EQUIPMENT NEEDS – Equipment requirements for augering depend upon the application. For example, if the auger works in conjunction with stripping a bulldozer and trucks will be all that will be needed. Service and maintenance trucks used for the stripping equipment can take care of the auger. If augering is done independently of stripping, either in abandoned strip pits or in areas where no stripping was done, a small shovel and service facilities probably will be needed. The shovel will be needed to provide a working bench along the outcrop or help the bulldozer clean old pits.

AUGERING RESULTS–At one West Virginia operation where a 48-in auger recovers 400 tons per shift, three men perform all the work connected with augering. One man operates a bulldozer to move the auger to new drilling sites and to clean the pit in the augering area. The other two men operate the auger and add or remove auger sections.

Coal from the auger is discharged onto the ground adjacent to the highwall. When a good size stockpile has been built up, the coal-loading shovel moves in at a convenient time and loads it (*Coal Age*, September, 1956, p 64).

Among the latest machines in operation is a self-moving 48-in. unit that works in a mountaintop pit only 26 ft wide. Self positioning with three hydraulic positioning jacks make it possible for the unit to be moved fast and easily to a new hole site (*Coal Age*, September, 1956, p 72).



BREAKING COAL with a tractor-mounted hydraulically controlled ripper is proving an effective aid in keeping production cost to a minimum. Powerful bulldozers make ripping possible in seams up to 6 ft thick.

Three augers, two full time and one spare, are used at this property to recover coal that could not be stripped because of the hazard of spoil rolling or sliding downhill and damaging vital mine installations.

In Ohio, a 30-in self-moving auger produces 400 to 500 tpd in three-shift operation. Working in areas previously deep mined, the unit has produced up to 275 tons in a single shift (*Coal Age*, July, 1957, p 60).

Production of 150 tpd with only six men, including truck drivers, is achieved with a 24-in auger. The company uses trucks for overnight storage to get full-shift operation. Four trucks are used regularly by the two drivers. While they shuttle back and forth between the pit and cleaning plant, the elevator operator spots empty trucks. When a truck is filled it is driven from under the elevator and parked headed toward the preparation plant. When a driver returns with an empty truck there is a loaded one waiting for him (*Coal Age*, December, 1956, p 54).

A new entry in the auger group is a twin-head machine capable of boring two holes at the same time. The unit breaks out the small pillar between the two holes and thereby increases recovery. Capacity is boosted and as a result, thinner seams that previously could not be mined profitably now may be recovered.

Coal Loading

Balance coal loading capacity with stripping capacity.

Use bulldozer, motor grader or power broom to clean top of coal before loading. Employ hand cleaning where power units cannot remove impurity from irregular seam.

Consider special machines for loading thin seams.

Improve loading rate by blasting or breaking hard seams.

Should coal be blasted before it is loaded? The answer to that question can be found only after making a through study of the conditions at a particular mine. And even then the conditions may change from time to time so that no hard and fast rule can be set up.

Where the coal is of average thickness and hardness, explosives used in breaking the overburden usually will loosen the coal sufficiently so it can be loaded easily without being blasted. But sometimes it is too hard to be broken this way or the nature of the overburden may prevent it.

At other operations, it is necessary to drill and shoot the coal in a separate operation. Self-propelled combination machines made up of drills, compressors and brooms are gaining in favor for this work. Either one or two drill arms are mounted on these units to put down holes in a minimum of time. The power broom is used to sweep the top of the coal before holes are drilled in the coal and is disengaged from the power unit when the combination machine is used for the drilling job. Sometimes a handpulled wagon with a gasoline-powered drill is satisfactory.

Still another tool for preparing thin seams for loading is the pinning machine. This unit travels over the coal on crawlers, dropping a weighted, pointed steel pin or pins that pierce the coal and fracture it enough to permit easy loading. The advantage of this machine is that the coal can be broken as quickly as it could be drilled, the cost of explosives is eliminated and a minimum of fines is produced.

RIPPING COAL—A new concept in strip mining—breaking coal with a tractor-mounted ripper—is proving an effective and economical aid in keeping cost to a minimum. The new technique is made possible by the recent development of large hydraulically controlled rippers mounted on the rear of tractors having engines with more than 300 hp. Unlike former towed rippers which simply trailed the prime mover and exerted no down pressure, the tooth of the mounted ripper concentrates the entire weight of the tractor for maximum penetration.

With tractor weights approaching 70,000 lb, only the tractive effort of the prime mover and the size of the tooth limit the depth of penetration. Ability of the modern tractor to develop up to 54,000 lb of pull at the drawbar makes ripping possible in seams up to 6 ft thick. In an Illinois mine, a tractor-mounted ripper with an 8-ft tooth breaks a 4½-ft seam of coal at a saving of $42,000 per year over conventional methods. (*Coal Age*, February, 1958, p 148).

Coal Cleaning

Preliminary cleaning before loading, where desirable, can be done by tractor-scrapers, bulldozers, graders, rubber-mounted scoop loaders or power sweepers. If there are any clay veins in the coal or the top of the coal is very irregular, it may be necessary to remove part of the dirt by hand. Hand cleaning, however, is expensive and should be avoided where possible.

Loading Methods

There are available for the loading

job a variety of units with capacities and design features to fit any pit condition. First consideration in choosing a coal-loading machine is to get the right capacity. This means matching loading capacity to the stripping capacity. In some cases it might be desirable to have some excess capacity in the coal shovel in case of hard digging, or transportation or tipple delays that jam up empty trucks at the loading point. By loading trucks rapidly with an oversize shovel, the haulage cycle can be put back to normal in a minimum of time. Thus the plant can be fed uniformly with few surges.

SPECIAL SHOVELS – If the coal seam is thin, it is well to consider the horizontal-thrust shovel or the skimmer unit, either of which moves the dipper parallel to the bottom while loading. These units have the advantage of scooping up a wide channel of coal without disturbing the bottom. In other instances, a conventional shovel equipped with a specially designed dipper is a satisfactory unit for loading thinner seams of coal.

SPECIAL DIPPERS–If the coal seam is split into two or more parts by several feet of rock, the specially designed dipper on a conventional shovel may work out better. The top layer of coal can be scooped off and then the same shovel can be used to remove the rock covering the lower portion of the seam. If the coal loader cannot be spared for the rock job, the regular stripping unit can be used on the off shift to remove the thin layer of rock.

When the coal is more than 2 or 3 ft thick, but is extremely hard, a divided dipper can be used effectively to limit the size of lump that is delivered to the truck and therefore to the preparation plant.

To minimize spillage when loading the top seam into trucks on the lower seam, a special variable-rake-angled dipper was developed. The dipper is set for the proper rake angle for digging, then when raised for dumping the angle is readjusted through a control in the operator's cab to the proper angle for low dumping. Afterwards the rake angle is reset for digging.

STOCKPILING–Where two-shift operation of the preparation plant is not desirable and the coal is thin, top efficiency from the loading and hauling units can be achieved by heaping the coal to one side of the pit on the off shift so that loading time will be as low as possible on the regular shift. The loading shovel thus can fill a truck faster and coal will be carried to the tipple faster.

INCREASING COAL RECOVERY–The importance of recovering all the coal that is uncovered cannot be overemphasized, particularly where the seam is thin. If by careless operation of the coal-loading shovel 3 in of coal is left on the bottom over an area of one acre, the loss will be about 450 tons. If 10 acres of coal are stripped in a month, the resulting total loss will be 4,500 tons. At a sales price of $4 per ton, his amounts to $18,000 per month.

If working completely to the bottom results in much over-shooting or in too much loss of time, and there is considerable coal involved, a bulldozer may be assigned to accompany the loading shovel. It can rip up the bottom coal–with the aid of scarifying arrangements if necessary–and keep it pushed up to the loader with a minimum of digging into the bottom and at a cost still representing a considerable saving over leaving the coal or delaying the loading. If a washing plant with sufficient capacity is available some bottom material can be tolerated with either shovel or bulldozer cleanup. If a washer is not available, more care is required, but it still is possible under many conditions to increase recovery without undue contamination.

Another place where good loading procedure pays off is along the outer edge of the coal where it is in contact with the spoil. If a 6-in strip of coal is left along 1 mi of a seam of coal 60 in thick, the loss will be about 528 tons of coal. At $4 per ton, this will be $2,112. To provide a solid vertical edge and prevent losses such as this, one company developed a marking machine that shears through the coal, marking the loading limit for the shovel and leaving a smooth vertical wall on the bench. Estimated savings were about 200 to 400 tons per acre.

Transportation

Match size of trucks to loading capacity of loading shovel.

Select truck with shortest turning radius possible for easy turning in the pit.

Consider torque-converter trucks where steep grades will be encountered.

Where conditions otherwise are favorable, check into the possibilities of the overland belt for savings in roads, trucks and maintenance.

Consider hydraulic retarders for controlling truck speed on long steep downgrades.

Investigate possibility of combination of truck and rail haulage where haul is long, topography is favorable and reserves ample.

Good haulage depends upon modern equipment installed and used in a workmanlike manner. The rugged end-dump truck and semi-trailer are the favorites for coal haulage, with the overland belt from pit to preparation plant an added starter in the transportation field. To pick the most suitable equipment or combination of units for the best haulage results, a careful analysis must be made of the job to be done.

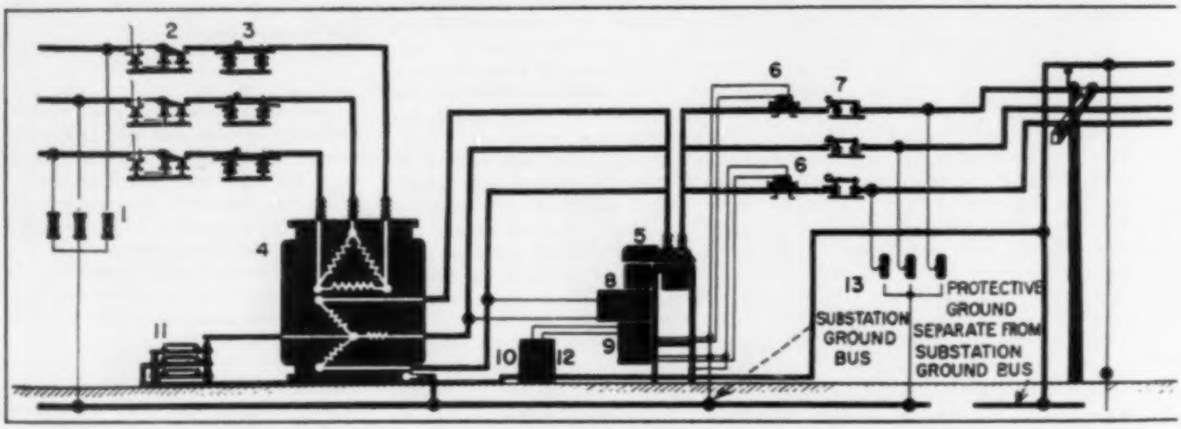
SELECTING TRUCKS–Choosing the largest available unit does not always result in a lower cost per ton because final truck selection is based on many factors including production, pit width, types of roads, grades, distances and size of loading shovels. Wherever possible, the size of the haulage unit should be matched to the size of the loading shovel. For example, a 5- to 7-yd shovel works well with a 40-ton truck and a 3- to 4-yd shovel teams well with a 25-ton hauler. A good rule of thumb is to use trucks with four to five times the dipper capacity of the shovel.

Over-all height of the truck should be such that it makes a good target for the loading shovel. Length should be a minimum and width a maximum so that the shovel loading cycle can be kept to a low value. Ability of a truck to turn around in cramped quarters in as short a time as possible and get under the shovel without delay should be considered to avoid traffic congestion.

Coal-hauler size runs up to 50 tons in anthracite, and up to 80 tons with tractor-trailer units in bituminous. Power is supplied by engines up to 400 hp. In recent years trailer weight has decreased, and payload and speed have increased by 25 to 30%.

NEW TRUCK DESIGN–New ideas constantly are being introduced in truck design to increase payload or improve performance. For example, tractor-trailers which recently went into service at an Illinois mine feature a tractor that has no front axle. Instead wheels are mounted individually on a spindle which in turn is fastened to a hydraulic shock absorber. The suspension units act as giant kingpins and support the front wheels while making it possible for them to be steered. Two of the units replace the front axle, two are used to spring the drive axle and two support the trailer axle.

With few minor changes, one is also used to connect the trailer to the tractor. One advantage of this type of connection is that the loaded trailer is carried on a cushion of air; hence,



1 **LIGHTNING ARRESTERS**—for protection against high-voltage surges on the high line.

2 **DISCONNECTING SWITCHES**—for disconnecting substation from high line.

3 **BA FUSES**—for short-circuit protection.

4 **TRANSFORMER**—may be either three single-phase units or a single three-phase unit.

5 **OIL CIRCUIT BREAKER**—for short-circuit and ground-fault protection on distribution lines.

6 **CURRENT TRANSFORMER**—for use with type CO over-current phase relays.

7 **DISCONNECTING SWITCHES**—for disconnecting distri-

Components of an Open-Pit

shocks are absorbed by the connecting member rather than transmitted directly to the tractor. Another advantage is that the connection is located 30 in ahead of the centerline of drive axle and thus gives capacity loading of the front axle.

A special airplane-type propeller cooling fan is used on the engine, saving 66⅔% in the power required for cooling. Controlled thermostatically, the fan runs only when engine temperature is above 190F.

The use of Manten S alloy steel for fabricating trailers capable of carrying 80 tons of coal results in more payload per trip. Other improvements in design make it possible for the unit to carry 4.4 cu yd per foot of trailer compared to 2¾ cu yd in a conventional trailer.

TORQUE CONVERTERS—Torque converters make for smooth truck operation, less lugging and lower maintenance. They also have made it possible for loaded trucks to climb steep grades, thus shortening haulage routes. In some cases, a 48-ton truck with torque converter can haul coal at up to 30% less per ton-mile than a 37 ton truck with a standard transmission on the same route.

AIR STARTERS—Air starters have been used effectively on large coal haulers to eliminate all batteries except the 6-v units for headlights. Starters are operated by compressed air supplied at 100 psi from a storage tank on the tractor. Trucks can stand idle for 4 or 5 days and there still is enough air in the tanks to start them.

HYDRAULIC RETARDERS—Hydraulic retarders are now available for controlling the speed of trucks on long steep downgrades. The unit also acts as a governor. Mounted on the drive shaft of the truck, the device is designed so that when the shaft speed increases, the retarder resistance automatically increases at a much faster rate. Therefore any tendency of the truck to run away is curbed by the retarder which piles up resistance very rapidly when the truck's speed tends to increase. A control valve near the driver regulates the degree of braking available by controlling the oil passing into the retarding device. Aside from slowing the truck, the device is said to save tires, fuel, time and brake lining.

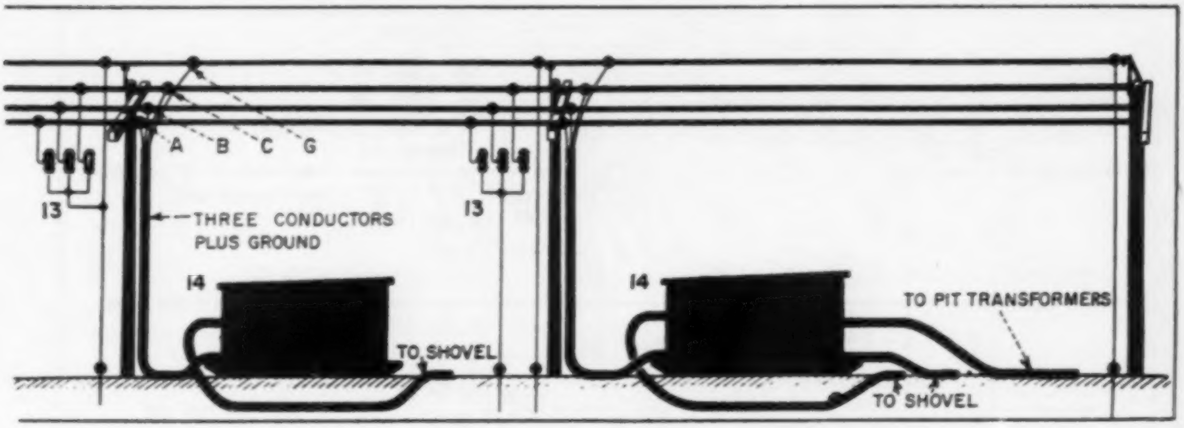
TRUCK-RAIL HAULING—Where the haul is over 3 or 4 mi, the topography is favorable and sufficient coal reserves are available, the use of a field station and rail haulage to the preparation plant is worthy of consideration, particularly since the advent of the small diesel locomotive. With this type of setup one man can load a trip of cars, haul it to the preparation plant, dump it and return to the field station in a minimum of time. A minimum of trucks are needed to shuttle back and forth between the pit and the field station. Consequently, truck maintenance costs also are lower and fewer men are needed for operating and servicing trucks. A further advantage is that road maintenance will be lower.

OVERLAND BELT—An added starter in the transportation field is the overland belt system that carries coal from portable bins near the pit to the cleaning plant (*Coal Age*, August, 1954, p 64). Where the land is gently rolling and stripping can be carried out in a wide area, the overland belt offers the following advantages:

1. Eliminates the cost of building and maintaining long high-speed haulage roads.
2. Permits movement of larger tonnages with fewer and/or smaller trucks.
3. Permits recovery of belt after the property is worked out. Roads cannot be recovered.
4. Reduces the manpower required for maintenance of trucks.
5. Requires a smaller supply inventory and less garage space.

Road Building

Where haulage is completely on roads, it is of vital importance that a good running surface be provided. Main roads should be built with wide beds and have



Power Distribution System

bution lines from substation.

8 CAPACITOR TRIP DEVICE—providing a source of energy for tripping oil circuit breaker.

9 TYPE CO PHASE RELAYS—for short-circuit protection.

10 TYPE CO GROUND RELAY—for ground-fault protection.

11 GROUNDING RESISTOR—for limiting ground-fault current.

12 CURRENT TRANSFORMER—for use with type CO ground relay.

13 LIGHTNING ARRESTERS—for protection against high-voltage surges on distribution lines.

14 PORTABLE SWITCHHOUSES.

good alignment to permit trucks to run at top speed. All curves beyond the gentlest should be superelevated. Roads should be planned well in advance and when fills are needed to get the proper grade, they should be built up well ahead of the time they are needed. Fills should be compacted as they are made and topped off with one or more feet of rock that will serve as a road base. After this material is compacted, a top layer of crushed rock should be added and compacted. This top layer usually is applied in several layers and compacted between each. Material used for the top layer includes Nos. 3, 4 and 6 crushed limestone, 2-in slag or red dog.

SURFACE MAINTENANCE—One or more road graders, depending on the length of road to be maintained, are used at most operations to keep the running surface smooth. Roads should be sprinkled regularly during the dry, dusty season not only to maintain good visibility but also to keep dust out of truck engines and moving parts thus helping to reduce maintenance needs.

EFFECT OF GRADES—Grades should be avoided as much as possible to keep power requirements down. For example, it takes twice as much force to move a 20-ton load up a 5% grade as on the level. Where grades must be negotiated, stepped-type roads can be used to advantage. This type of road involves alternate stretches of level road and short comparatively steep rises. There fore less clutching is required in trucks equipped with standard transmissions and there is less lugging on the up grade and over-speeding on the down grade. Constant shifting and lugging results in reduced life for engine, transmission and clutch.

Entrances to the pit should be one way if possible. Turning and backing large haulage units takes time and thus reduces haulage efficiency. Proper design of turn-ins can eliminate this problem.

SNOW REMOVAL—In winter roads should be cleared of snow before trucks start to operate. This will prevent formation of slippery conditions caused by compacted snow. A motor grader, started several hours before trucks begin to travel, should be able to clear an average snowfall. If there is a severe storm, bulldozers should be added to help move the snow off the haulage roads.

Power

Buy power at highest possible voltage to get the most favorable contract possible.

Provide adequate protection against ground faults.

Use Type SHD cables for portable service, preferably in 1,000-ft lengths.

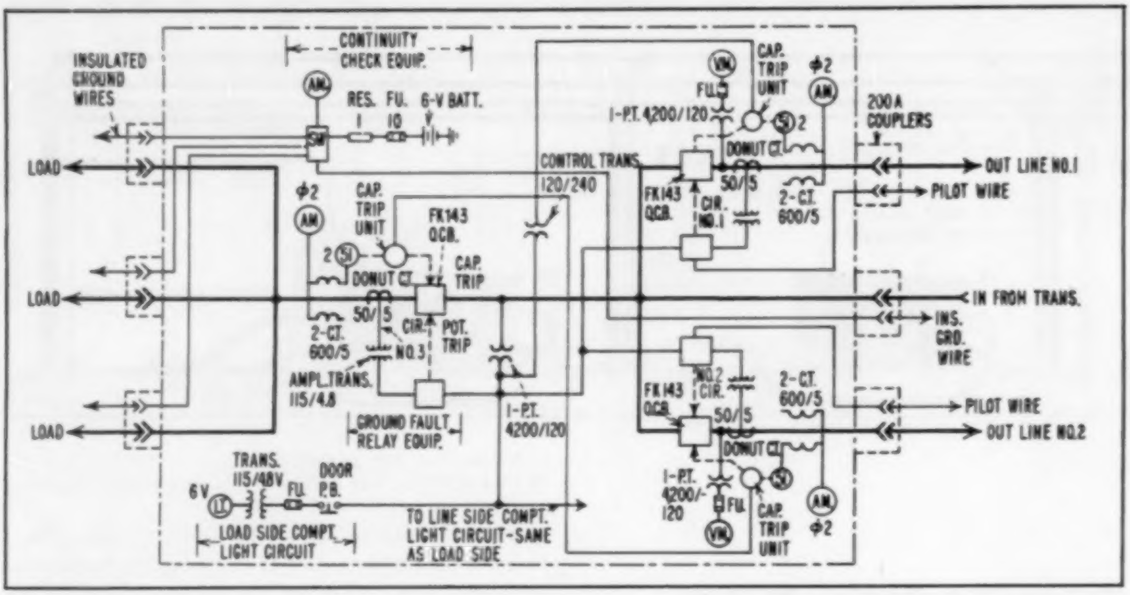
Consider parallel operation of portable substations at large operations.

Consider less expensive special-type mine power cables for exclusive use between breaker skids on the highwall.

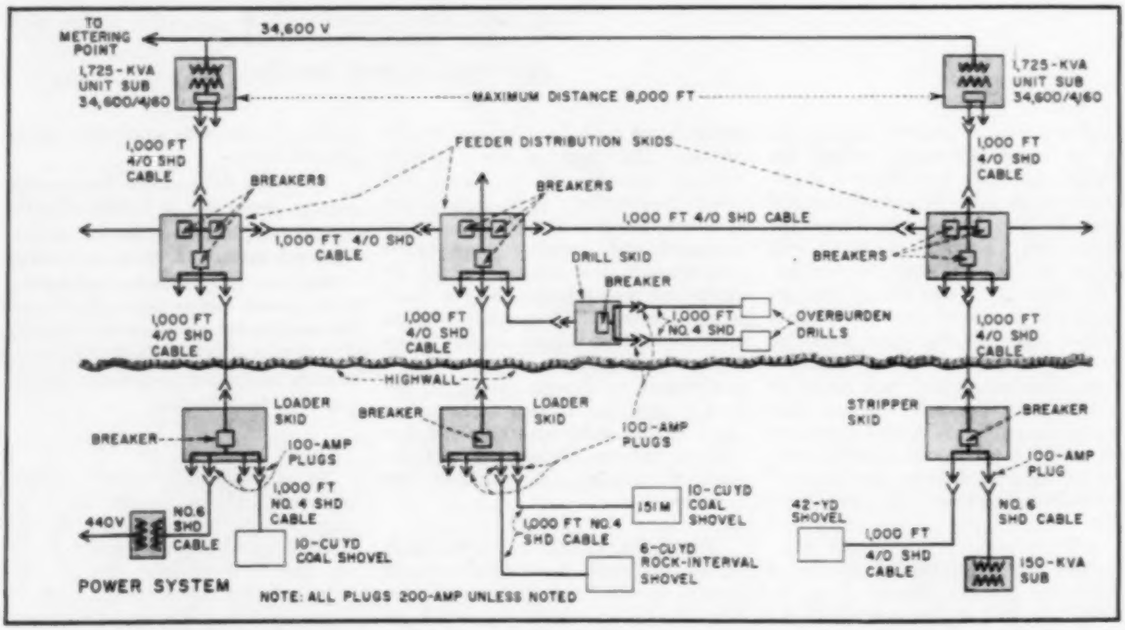
Emphasize cable maintenance and provide necessary equipment for testing and fault-finding.

The increased load demands of higher powered machines requires more and more thought in planning the distribution systems supplying pit power. In laying out a distribution system, three primary factors are involved. First, the system must be able to supply the equipment without objectionable voltage regulation from an operating standpoint and at the same time stay within reasonable economic limits. Second, the system must provide adequate protection for personnel and equipment. Third, the units in the system must be adaptable to relocation to keep up with the change in the load requirements.

Public utility companies supplying the energy for operating strip mine equipment are faced with the problem of greatly increased demands on their systems. Many times they have been able



ONE-LINE DIAGRAM of triple-breaker skid shows how ground-fault and continuity-check circuits are built in.

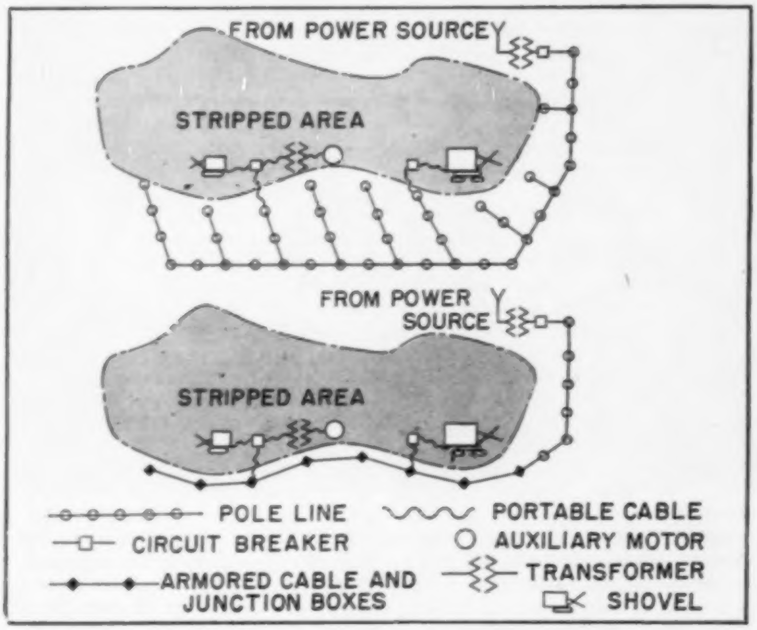


HOW power is distributed in loop system that has two easily moved skid-mounted substations plus portable auxiliary units.

to handle this increased capacity by switching to higher voltage transmission lines. Mining companies using large quantities of energy can get a more favorable contract if they receive power at the higher voltage. To do this the customer must purchase a transformer substation capable of reducing the voltage to that required for the portable equipment.

Energy is now often received and metered at 33,000 or 66,000 V. Thus the user builds the higher voltage transmission lines from the metering stations to the portable substation units located near the area to be stripped.

TRANSFORMATION – Voltage may be reduced in either a one- or two-step transformation. With one-step transformation, primary mine distribution usually is 2,300 or 4,160, with 6,600 and 7,300 volts coming into the picture as a result of heavier demands imposed not only by the increase in machine use but by higher horsepower per machine. In two-step transformation, the "super-primary" voltage usually is 13,000. Permanent transformer stations may employ either single- or three-phase transformers, with a trend toward the latter. A number of strip operations also employ semi-portable stations completely or to



TODAY'S power distribution systems at strip mines include both lateral pole lines and armored cables.

supplement permanent stations. Commonly called unit substations, they are based on three-phase transformers. Typical ratings are 1,500, 2,000 and 2,500 kva, with the top usually 5,000. Normally these stations include lightning arresters, circuit breakers, ground-protective equipment and other central and protective facilities.

PRIMARY DISTRIBUTION—Primary distribution systems generally fall into two general classes:

1. Pole-mounted high lines.
2. Cable systems.

A third version is a combination of pole lines or lines and cable line or lines. Pole-line practice is largely standardized, with a main line a maximum of 1 mi in advance of the pit and parallel to it. From this main line, pole-line laterals at intervals of 1,200 to 1,500 ft are run to the pit, terminating in switchhouses which supply auxiliary transformers for low-voltage equipment, and also supply the cables on the larger high-voltage equipment. As the pit moves across country, the laterals are shortened at intervals until the pit approaches the main line, which then is moved to restart the cycle. Cables on the equipment usually are 1,000 ft long. Thus, with a lateral spacing of 1,200 to 1,500 ft, equipment can operate freely between laterals with enough cable to spare to permit terminating laterals some distance back when shortening is necessary.

SUBSTATIONS IN PARALLEL—The latest development in strip mine power systems is operation of substations in parallel (*Coal Age*, October, 1956, p 60). At the present time two skid-mounted 1,500/1,725-kva substations are in operation with plans for adding a third unit. The pit power distribution system is entirely by portable cables and multi-conductor plugs and sockets.

Special mine power cables are used between breaker skids. The cable is similar to the Type SHD portable shovel cable in that it has a copper basket weave over individual conductors. It differs in that it has smaller ground conductors and a thinner outer jacket. This type of cable was bought at a saving of approximately of 46%. It is used exclusively on the highwall and seldom, if ever, will it be necessary to move it while it is energized.

The theoretical ideal conditions for paralleling three-phase transformers are:

1. Same phase rotation
2. Same phase-angle shift
3. Same polarity
4. Identical turn ratios and voltage ratings
5. Equal per cent impedances
6. Equal ratios of resistance to reactance.

Since the substation units at this mine are identical, the last five items above are automatically taken care of. To parallel two or more substations phase rotation must be the same. Phase rotation refers to the order in which the terminal voltages reach their maximum values. In paralleling, those terminals whose voltage maximum occur simultaneously are in phase and are connected together by the circuit breaker. Each substation unit is equipped with necessary equipment that will not permit the breaker to be closed, paralleling two substations unless the voltages on both sides of the breaker are the same phase. Added safety features are incorporated within the substation design to indicate to the operator of the substation the unit voltage level and load at all times on both sides of the breaker.

GROUND-CABLE SYSTEMS—A fair number of strip mines use the "ground-cable" system instead of pole lines, or a combination of ground cables and pole lines. Otherwise, the basic plan is the same. A complete system consists of the main cable and the laterals, the cable being fabricated in sections of 1,000 to 1,500 ft as a rule with connectors for termination in switch-houses or for joining the main-cable lengths by junction boxes. Several types of cable may be employed but the most common is Type SHD. Construction includes copper shielding braid over each insulated conductor to equalize surface stresses and eliminate static discharge—the cause of corona cutting. The shielding must be at ground potential at all times, and therefore must be properly grounded, which also eliminates the hazard of shock in handling the cable. Grounding conductors are placed in interstices. It is the safest and most widely used for high-voltage (up to 15,000) portable power applications.

Within limits, distance of transmission of 4,160 volts becomes critical, as a rule, only with the heavy loads encountered in the use of large shovels and draglines rated from 20 to 25 cu yd and up

where connected horsepower per unit runs from approximately 2,000 to 5,000. Under such circumstances, the transmission distance for 4,160 volts normally should not exceed 5,000 to 6,000 ft. Above that, at high-voltage—33,000 for example—a pole line is cheaper to construct and also improves regulation and reduces power loss.

With the success of the 60-yd unit and advent of the 70-cu yd shovels, operating voltage moved up to a new high of 7,200 volts. Power is fed directly to the shovel cables from 5,000-kva transformers after passing through automatic circuit breakers.

The 6,900V cable to the 60-yd shovel has one of the three ground wires insulated and a 110-V potential is maintained between the uninsulated ground wire and the insulated wires. On the shovel there is an annunciator circuit connecting the insulated wire and the equipment frame. Thus any broken frame to ground conection will warn the operator of the fault.

CHOOSING PROTECTION—Primary items involved in the selection of a protective grounding system include:

1. The maximum value of machine frame to ground voltage during a ground fault.
2. The magnitude of fault impedance that can be relayed.
3. Provisions for checking continuity of the ground-wire circuit.
4. Establishing a protective ground separate from the substation ground.
5. Proper choice and rating of components to maintain low frame-ground voltage in event of failure to trip on a ground fault.
6. Immediate isolation of a faulted feeder from the remainder of the system.

FRAME GROUNDING—The frame-to-ground voltage that is developed under fault conditions is approximately the ground current times the impedance of the ground wire. This is the potential to which a man standing on the ground and touching the machine would be subjected to when a ground fault occurs.

In a system having a resistor limiting ground fault current of 25 amp where the ground-wire impedance in the cable is 2 ohms, the machine frame-to-ground voltage would be 50. In a system having a 50-amp ground current limit and a 2-ohm impedance in the ground wire, the voltage will be 100.

If more than one substation is used and each has its own ground-current limiting resistor to keep each ground current to 25 amp. paralleling them will permit a total of 50 amp to flow in the ground wire in event of a ground fault. The potential drop in the ground wire then would be 100 V. If more than two similar substations, each with its own ground-current limiting resistor, are used the total ground current that would flow in the cable ground would be the sum of all substations.

The grounding resistor will establish the maximum ground current that can flow under solid fault conditions. The tripping current that would isolate a faulted feeder should be considerably less. The ratio of limit value to ground relay pick-up value determines the fault resistance that can exist and still obtain tripping. The higher this ratio the greater the fault resistance can be for relay pickup. It is improbable that a high-resistance will clear, therefore its immediate isolation is advantageous. The ability to relay a high-resistance fault is important in safety grounding systems.

For example, one recommended plan uses a 25-amp ground-current limiting resistor and a ground-detecting transformer and relay combination set to trip at 5 amp ground fault. On a 4,160-V system this resistor value from ground to each phase would be 96 ohms. In a 4,160-V system the line to neutral voltage is 2,400. Thus a total resistance—grounding resistor plus ground wire plus 2,400 divided by 5, or 48 ohms and still obtain 5 amp in the ground circuit. Subtracting the 96 ohms of the resistor from the 480 ohms would permit 384 ohms in the fault. Thus fault resistance between 380 ohms and 0 ohms could be relayed.

Successful functioning of the safety grounding circuit depends on the ground conductors from the machine frame back to the substation being intact. If the ground is broken or an open terminal connection develops, the protection is impaired.

CONTINUITY CHECKS—There are various ways of checking ground-wire continuity. Sometimes a check is made at the start of the shift by imposing an artificial ground fault on the unit and noting tripping of the feeder breaker. The latest method is to provide continuous monitoring of the ground-wire circuit. Sometimes an alarm sounds in the equipment and warns the operator that the ground circuit is not intact. Other methods actually trip the supply breaker. In each of the continuous systems either a pilot wire is required in the cable or one of the grounding wires must be insulated from the other ground wires.

SUBSTATION GROUNDING—To minimize the rise in potential of the protective ground and the frames of mobile machines to which it is connected during the lightning arrester discharge, or in case of flashover of any of the substation equipment, the substation protective ground resistor should be connected to a separate ground. This ground should have as low a resistance as possible—under 5 ohms—and should be located some distance from the main substation ground.

BREAKER SETTINGS—Since one of the main purposes of the grounding system is to isolate a faulty feeder as quickly as possible, ground fault tripping on the breaker unit nearest the load should be made instantaneous. If there are other breaker units between the load and the substation, these should be set for the same ground current as the unit nearest the load but provide selective tripping on a time basis.

POWER FACTOR—To prevent power penalties resulting from power factor below that specified in the power contract, synchronous motors, 0.8 leading, are installed on the m-g sets on large excavating units. Without correction, power factor would usually average between 68 to 85%, but with the proper correction will be up to 90 to 95%, which will be above the penalty area.

CABLE TESTING AND FAULT-FINDING—Insulation failures and shorts in high-voltage distribution or service cables in strip pit can cause major delays unless special facilities are provided for locating them. Without such special equipment, about the only method is to apply high voltage and current and blow the cable up at the point of fault.

Equipment for testing and fault location may be made or purchased. A testing outfit that may be made up from purchased components employs, among other items, a half-wave rectifier tube and filament and plate transformers to produce DC at up to 30,000 V and 40 milliamp, or sufficient to test up to 7,500 V. In operation (*Coal Age*, May, 1953, p 108) voltage is applied slowly to one conductor, with other conductors, shield or shields and ground wire or wires grounded. When the cable is fully charged, the current flow is the true leakage current, registered on a milliammeter. The voltage is held for a period and leakage current is determined at intervals to develop a polarization curve. The shape of the curve indicates the electrical condition of the cable and exposes potential insulation weaknesses.

For locating faults, the test equipment is modified by the addition of a spark gap and condenser. Location is achieved by picking up the discharges sent forth by the condenser and spark gap, which are audible at the trouble spot if there is water soaking or there is not a dead short. Where this is the situation, the observer has only to walk the cable. If the fault resistance is very low, dead ground or under water, a

LOW-COST NEUTRALIZING of acid water in isolated areas is done automatically with portable unit powered by water. Stainless steel parts resist acids.

pickup coil and earphones are employed and the fault point is marked by a change in the signal. Commercially developed units may be purchased to achieve the same results.

Drainage

Prevent inflow to the pit whenever possible.

Employ gravity as much as possible to drain pit accumulations.

Consider automatic controls for pumps to cut labor cost.

Use check valves in suction lines to eliminate the need for priming.

Consider automatic lime-feeding devices for low-cost treatment of acid water in isolated areas.

The aim in drainage is to handle water as economically as possible. Good drainage procedures can pay off in lower material cost and less labor. Men and equipment also will perform better if the working area is kept free of water.

PREVENTING INFLOW—To keep drainage costs to a minimum, water should be kept from entering the pit and off the haulage roads. Several ways of doing this include: (1) diverting streams to new channels to prevent seepage into the work area; (2) ditching above the highwall to divert surface runoff away from the pit; and (3) building flumes to span the pit.

GRAVITY DRAINAGE—When water does enter the pit, as a result of rainfall or seepage, gravity should be used as much as possible to remove it. By exercising care in spoiling, leaving windows in the spoil areas or putting in crib culverts or drain pipes at intervals, water can be handled economically. If grades favor it, one end of the pit may be kept open to release all the water. In some cases it will pay to blast a ditch in the pit floor so water can flow by gravity to a drainway in the spoil.

PUMPING—Portable pumps, either mounted on skids or wheels, are the leaders where pumping is required. These are used in a variety of sizes and capacities, depending on the job to be done and are powered either by electric or diesel motors. Many of the units are controlled by float switches that stop or start them automatically, thereby cutting labor costs.

The hose is popular for temporary water lines but is frequently supplemented by a variety of new materials, including flexible plastic, special rubber and aluminum pipe. Resistance to corrosion, rot and abrasion have made plastic pipe more popular, while ease of handling makes aluminum desirable. Threadless couplings, in addition to the advantage of fast joining and installation of pipelines, also permit individual joints of pipe to be rotated 180 deg if a small leak occurs in the bottom as a result of abrasion. Thus pipe life can be greatly increased. Check valves should be included in all suction lines to eliminate the need for priming pumps. However, this may not be desirable in weather when there is danger of the lines freezing. If corrosion and abrasion are problems, impellers and pump interiors can be coated with rubberbase material to increase their life.

WATER NEUTRALIZING—To prevent acid water from entering the water sheds of surrounding streams, one company developed an automatic device that provides low-cost water neutralizing (*Coal Age*, February, 1957, p 101). Six sumps, each with its own pump, are strategically located on the property. Each pump has a separate automatic treating tank. Water is treated automatically with lime solution and delivered to settling areas before it is permitted to enter the water basins.

A steel mixing tank at each pump is partially filled with water and 400 lb of hydrated lime is added. As the lime enters the tank it is thoroughly mixed with the water by a power-driven agitator.

Lifting cups attached to one end of the agitator pick up the solution at one end of the tank and discharge it into an adjustable trough at the top of the tank. The trough leads to a 2-in hose that carries the lime solution to a point adjacent to the pump suction line. As the solution flows into the acid water it is pulled into the suction line of the pump. In the short journey to the pump and in the pump itself the solution is mixed thoroughly with the acid water.

A tank of solution lasts each pump for 2½ to 4 hr, depending on the acidity of the water. The quantity of solution delivered to the sump is controlled by moving the adjustable trough backward or forward.

An automatic lime-feeding device requiring no power other than the water itself provides low-cost water treatment in isolated areas at a Pennsylvania strip mine (*Coal Age*, March, 1958, p 148). Features of the unit include operation by as little as a 1½-ft fall of the water being treated; functioning on 5 gph or less; light enough to be carried to the site if necessary; automatic proportioning of lime according to volume of water being treated; adjustable lime feed to meet varying acidity; and 2 to 8 hr of operation without refilling.

The Preparation Guidebook

Practice Trends

STORAGE FACILITIES for both raw and clean coal being installed at an increasing number of mines.

FACILITIES FOR COMPLETE RECOVERY of useable material—coal, near-gravity material and fines—being included in an increasing number of plants, with emphasis on fine-coal recovery and beneficiation where the economics favor.

CONFORMITY WITH ANTIPOLLUTION REGULATIONS in addition to a desire to increase recovery resulting in major growth in the installation of facilities for clarifying water.

ULTRAFINE SCREENING being developed to assist in sizing and dewatering of the fines and ultrafines.

SATISFYING THE CUSTOMER is today, as always, the major objective in coal preparation. Though needs vary somewhat between customers—metallurgical and electrical-utility, for example—the four major keys to such satisfaction remain:

1. **Proper size** for the particular application

2. **Maximum Btu content** per dollar spent by the consumer through elimination of impurities and moisture. Good sizing also plays a part here, too, by making possible more complete combustion and thus more liberation of heat at the point where it can be effective.

3. **A high degree of uniformity** in all characteristics—size, heat content, ash and so on—meaning a product on which the consumer can depend day after day and year after year. Uniformity can be even more important than, for example, maximum impurity removal.

4. **Maximum convenience** in use. For example, should the coal be treated to eliminate dust in handling? Should the coal, if washed, be dried or treated with oil or chemicals to eliminate unloading and handling difficulties in freezing weather?

Satisfying the Market

First, it is assumed that the market today and in the future will require both sizing and cleaning, plus drying and other convenience treatment.

In setting up a preparation plant or system for attainment of desired sizing, cleaning, uniformity and convenience standards, the first job is to ascertain to the maximum degree possible what the market will require in:

1. **Size of product.** For example, the trend still is toward the smaller sizes, and is being accelerated by the growing use of coal by the electric utilities.

2. **Ash, sulphur, heat and moisture content.**

3. **Dustproofing, freezeproofing** and other convenience factors.

Next, the coal itself must be studied. It may, in its natural state, provide some of the desirable qualities—or in some exceptional cases, all of them. Where it doesn't provide them, can it be treated so that it does? The latter question usually is the critical one. It may be possible to process a certain coal to meet very rigid requirements for ash, but in the processing it may be necessary to reject an excessive percentage of the raw feed. Therefore, when all the pros and cons are weighed, a greater realization may be secured by a higher ash and a higher

recovery with a high degree of uniformity in the final product.

Achieving Low Cost

Control of plant cost is to some extent in the hands of the operator and to some extent not. If the market requires dried coal, the operator perforce must install drying equipment or suffer a handicap in his selling operation. Increases in plant cost may be mandatory for other reasons.

Expenditures which may be optional and thereby are within the control of the operator might include, for example, recovery and dewatering equipment for sludge, or for the finer fraction of a sludge or slurry product, if, as an example, it was possible to recover 2 tons of minus 28M with an acceptable quality, but such recovery required evaporating 5 tons of water at $2 per ton, it probably would be better to spend the money, other things being equal, on mining fresh coal. However, if it is necessary to put in equipment to recover and dry the coal to prevent stream pollution, then an additional expenditure for cleaning equipment—flotation, for example—might well be worth while from the standpoint of value received.

Raw-Coal Storage

PURPOSES:

1. Preventing interruptions in mine operation from shutting down the preparation plant and vice versa.

2. Providing some degree of blending of the raw feed to the plant.

3. Providing a means of evening out the flow of coal to the preparation facilities, thus permitting washing equipment, for example, to do a better job.

Capacity

Even where raw-coal storage facilities are underground, the prevailing practice is to provide at least ½ hr of the rated capacity of the mine or plant, with 15 min as about the minimum for anything more than a hopper to hold a car or two. From 15 min to ½ hr also seems to be the rule at most strip-mining operations receiving coal from trucks.

A trend toward even larger storage capacity seems in evidence, however. Examples include the following:

Deep mine, one 1,000-ton storage silo for plant capacity of 7,500 tpd (*Coal Age*, October, 1957, p 76).

Strip mine, 500-ton mine-run hopper supplemented by overflow ground storage for capacity of 1,000 tph. Future slope mine will have 5,000-ton hopper (*Coal Age*, February, 1958, p 76).

Strip mine, two 1,500-ton silos in addition to original 1,000-ton track hopper for storage and blending for plant producing nearly 8,000 tpd (*Coal Age*, July, 1958, p 74).

Where ground storage is provided, capacities up to 2 or 3 days are provided in some instances, as follows:

Deep mine, bin over slope belt with feedback belt from preparation plant, 10,000 tons, including ground area around bin.

Deep mine, ground storage with feedback belt over glory hole back to slope belt, approximately 1 day.

Strip mine, ground storage fed by stacker belt and spiral lowering chute; capacity, 5,000 tons; reclamation by feeder and belt (*Coal Age*, August, 1954, p 64).

Strip mine, two 5,000-ton stockpiles, one for each of two seams mined; piles fed by reversible stacker belt and lower-

Operating Reports

Barge Loading—Six types of barge-loading plants to meet various loading and river conditions. *Coal Age*, December, 1956, p 58.

Oil-Treating Guide—What to use oil for, oil selection, and treating methods. *Coal Age*, January, 1957, p 78.

Coal-Weather Treatment—How coal and cars are sprayed with oil to reduce freezing; quantities and costs. *Coal Age*, February, 1957, p 75.

Heavy-Medium Processing With Desliming—New processor designed for recirculation of 95% of medium within vessel. Screen and sump handle desliming. *Coal Age*, August, 1957, p 62.

Low-Level Plant—Low-height plant without internal conveyors built alongside tracks rather than over them. Conveyors to tower with 2-way chutes handle loading. *Coal Age*, September, 1957, p 74.

Processing 7,500 TPD—New plant includes sand-flotation equipment, wet tables, mechanical and thermal driers, thickener, filters and shuttle-belt loading. *Coal Age*, October, 1957, p 76.

Fine-Coal Jigs—New units with beds formed from plant refuse clean from ¼ in down, reducing ash from 25 to 40% to 7 to 8%. *Coal Age*, October, 1957, p 94.

Automatic Refuse Pumping—How ponds, pipelines and automatic pump controls dispose of ¼x0 refuse. *Coal Age*, November, 1957, p 72.

Pollution Prevention—Settling-pond system handles 500 to 550 gpm from filters and other sources. *Coal Age*, November, 1957, p 84.

Flocculation Improves Filtering—Report on USBM tests of flocculants and how they improve the filtering operation. *Coal Age*, December, 1957, p 74.

Preparation, Clean-Coal Storage, River Loading—New 1,000-tph plant includes primary and secondary washing, crushing, sizing, dewatering and drying, and two 1,400-ton bins for prepared 1x¾ and 1x0 coal. Floating-barge plant handles river loading. *Coal Age*, January, 1958, p 76.

Tipple Dust Control—How special dust-allaying compound is used. *Coal Age*, February, 1958, p 154.

Preparation Design—Key items to be considered in planning and design. *Coal Age*, March, 1958, p 100.

Three-Product Cleaning—Jig and heavy-medium unit provide three products in a flexible design. *Coal Age*, April, 1958, p 122.

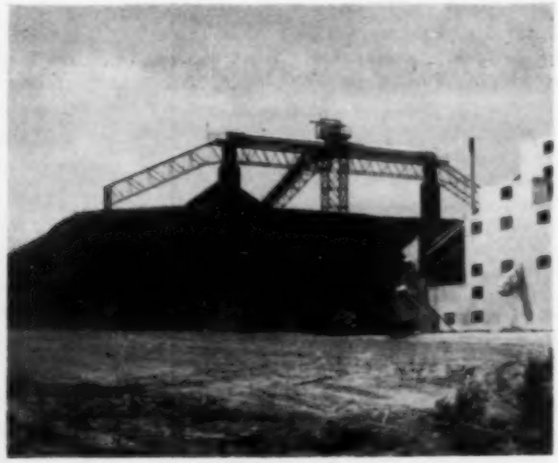
New Heat Drier—Heavy-media preparation addition includes new thermal coal drier. *Coal Age*, May, 1958, p 100.

Automatic Car Loading—Special hoists and sensing switches control loading of railroad cars without operator attention. *Coal Age*, June, 1958, p 94.

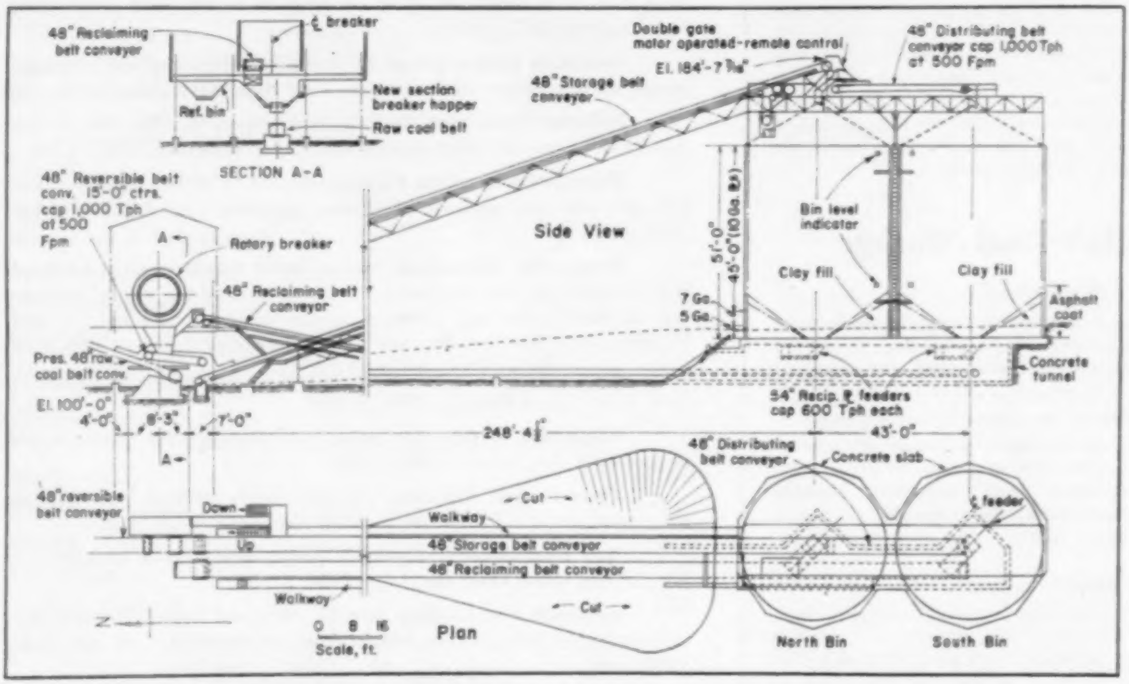
Raw-Coal Storage—Dual-bin installation for storage and blending, among other things, materially increases plant output. *Coal Age*, July, 1958, p 74.

accompanying illustrations. In one, ca-

STORAGE WITH FIXED-DISCHARGE STACKER providing a capacity 5,000 tons.



STORAGE WITH REVERSIBLE STACKER BELT results in two conical piles, one for each seam.



STORAGE IN DUAL BINS provides for blending in addition to a capacity of 3,000 tons of raw coal. The bins are preceded by a rotary breaker and supplement a dump bin with a capacity of 1,000 tons.

ing ladders; coal reclaimed by feeders under piles delivering to blending belt (*Coal Age*, October, 1956, p 60).

Underground Storage

Capacity of one hopper feeding a slope belt at a plant rated at 500 tph is 260 tons. The hopper is 16 ft wide and 66 ft long. Maximum depths is 18½ ft. Designed to receive coal from a belt system this hopper is fitted with a shuttle-type distributing conveyor with hinged boom end. The boom section permits laying coal into the hopper with minimum degradation. The shuttle principle also makes possible maximum use of bin capacity.

The dumping characteristics of drop-bottom cars also permit maximum use of bin capacity and thus can cut down size and depth; for example 96.7 tons in a bin 40x12 ft by 10 ft deep.

Size of underground hoppers occasionally reaches as much as 2,000 tons. Usually hoppers of this size are employed where there are two seams close enough together so that the hopper can be excavated in the interval to receive coal from drop-bottom cars.

Surface Storage

Although some form of bin or hopper still is the most popular form of surface storage of raw coal there is as previously noted a trend toward open or ground storage.

Two examples of surface storage designed to permit return of the coal via the main slope belt are shown in the

accompanying illustrations. In one, capacity is 200 tons in the form of a glory hole. However, if the discharge end of the recirculation belt was elevated and a bulldozer or dragline was added, as in certain other installations, capacity could be raised to 10,000 tons or more. In the second design, additional capacity is attained by using a hinged stacker belt. Here, too, capacity may be increased by lengthening the stacker belt and adding a bulldozer, dragline or other reclaiming unit.

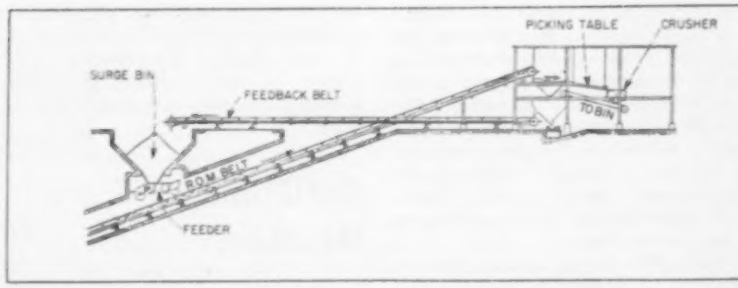
Even where slopes are not involved, the trend today with large storage setups is to use belts for both stacking and reclaiming. A single pile may be laid down in the form of a cone by discharge from a stacker belt with a fixed end. Or the stacker belt may be arranged with one end on a truck running on a curved track so that an arc-shaped pile can be formed. Or a strung-out pile of any desired length can be formed by using a stacker belt equipped with a traveling tripper. Straight or conical piles lend themselves better to reclamation by subway conveyor, now the usual practice.

DOUBLE PILING—Double conical piles may be formed by feeding to a reversible belt. By the proper arrangement of feeders and short reclaiming belts, coal may feed out of either or both piles for preparation alone or as a blend. Another method of forming double conical piles is by the use of boom conveyors preceded by a flygate as shown in the accompanying plan. In this instance, the bottoms of the cones are in pits formed by excavating to make it possible to feed the coal out completely without supplementary equipment.

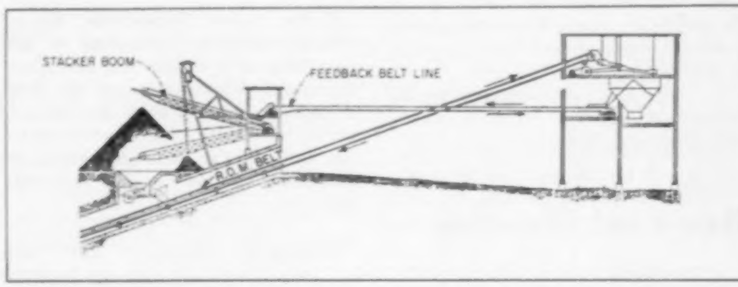
If the piles are placed flat on the surface of the ground it usually is necessary to employ a bulldozer, scraper or other unit to move the coal to the feeder after the natural center draw is completed. Boom-type stacking conveyors also provide one answer to the problem of reducing degradation in piling. With fixed-discharge conveyors, lowering spirals or ladders normally are required.

The plan illustrated also exemplifies a common practice in storing raw coal, i.e: preliminary reduction in size and rough cleaning in a rotary breaker. The flygate in this particular installation is remotely controlled, electrodes are installed on the ends of the boom conveyors to raise them automatically when the coal level reaches them. One of the funnel-shaped storage pits has a capacity of 3,000 tons; the other 1,500 tons. Feeders under the pits put the coal on the reclaiming conveyor. A more uniform raw feed to the plant, with better final quality, is one of the advantages.

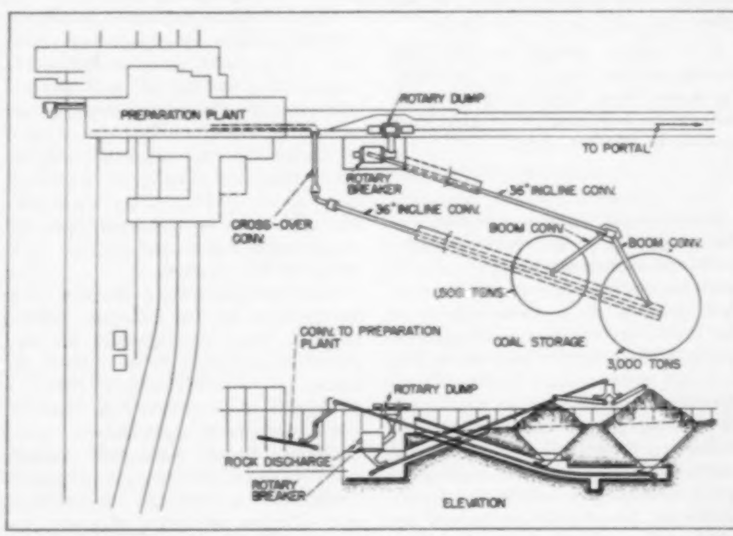
Ground storage may be accomplished by dumping from trucks in a flat pile with bulldozer spreading. Reclamation may be by standard shovel and trucks or by tractor-mounted shovels.



RETURN VIA SLOPE BELT is a feature of this ground-storage plan using a feedback conveyor to place the coal in a hopper. Storage with this system is limited by the size of the hopper or surge bin.



INCREASED CAPACITY in ground storage over slope belt is provided by stacker boom. Raising end of feedback belt and using a bulldozer or dragline for reclaiming is another method of increasing capacity.



GROUND STORAGE here involves rough cleaning, distribution to two funnel-shaped pits by boom conveyor, and reclamation by feeders to subway conveyor. Storage and reclamation is either automatic or remotely controlled.

BIN STORAGE—The conventional square or rectangular bin—steel, concrete or timber—still is the most-used method of providing raw-coal storage where open or ground storage is not employed. Two old hopper cars, one on top of the other, have been used in some instances. However, the round, or silo-type, unit is being increasingly installed. The silo may be built by conventional concrete-pouring methods or may be constructed of regular plate or prefabricated steel sections, or of precast concrete staves bound with steel hoops. A silo 24 ft in diameter and 55 ft high

will hold up to around 600 tons of coal.

Compartmented or multisilo bins are employed at a number of mines for greater flexibility in storage and also to provide some degree of blending of the raw product. Distribution to a side-by-side or four-cornered multiple unit may be by chutes and flygates. Indicators and remote-controls permit operation of gates and proper distribution without having a man at the bin.

Distribution to long multicompartment bins may be handled by a distribution belt with tripper. Other methods include a wheel-mounted shuttle belt similar to that employed in loading railroad cars which is moved back and forth to place the coal in the proper compartments. Or a scraper conveyor with fixed openings or movable gates may be used.

In deep bins, degradation may be reduced by installing spiral or ladder-type lowering units.

Raw-Coal Blending

PURPOSES:

1. Assuring maximum uniformity in the characteristics of the coal fed to cleaning units and thus in turn, assuring a better final product by enabling the units to do a better job.

2. Providing storage capacity and evening out the rate of flow to cleaning units, thus helping to promote uniformity and quality in the final product in another way.

Since the usual goal in blending raw coal is splitting it up into small increments and then recombining it, also in small increments, the normal blending plant consists of a multicompartment bin with a relatively large capacity—usually 1,000 to 2,000 tons or more. The more the compartments, within reasonable limits, the more the opportunity for splitting and recombining. Also, to facilitate putting small portions of coal into each compartment, the usual practice is to employ a belt with a traveling tripper, though other methods of distributing the coal may be employed. To complete the recombining—and blending—coal normally is withdrawn from all compartments at the same time. Variable-speed feeders are common for this purpose.

Normally, the coal is placed in the blending plant after preliminary cleaning and crushing.

A less-common type of blending is getting the desired mixture of coal from, say, two different seams. This requires a bin or set of bins for each, which may be filled in any of the usual ways, including dumping directly from mine cars or from railroad cars at a central or "milling-in-transit" plant. Blending of two coals also may be accomplished by feeding as desired from side-by-side ground-storage piles to a plant feed conveyor.

Preliminary Breaking

PURPOSES:

1. To reduce all oversize material in the raw feed to a certain top size, say 6 in.

2. To reduce extra-large lumps without especially attempting to get everything to a certain top size. Convenience and smoothing out the flow of coal through the plant are the major objectives. Freeing bone or partings from coal to facilitate picking or cleaning is another in some instances. instances.

Preliminary breaking and certain rough cleaning usually go hand in hand, although, for example, if coal is being transferred from a hopper to a crusher preceding a slope belt underground, no attempt is made as a rule to remove rock or impurities before the breaking process. On the surface, however, it is generally accepted that where substantial quantities of rock are encountered it is best to remove at least part of it before sending the product to the crusher. Consequently, particularly where all the coal is to be washed, it is common practice to employ a picking table or—as is increasingly the case—a scalping screen and picking table ahead of the crusher.

Preliminary breaking is almost entirely the province of the roll-type machine although some pick breakers are employed to get closer to the desired objective of reduction with a minimum production of fine sizes. Roll diameter, tooth design, tooth positioning and speed are major factors, along with keeping teeth in good condition at all times. Double-roll crushers are considered to give a higher proportion of coarse material because abrasion against the plate is eliminated. Feeding practice also influences results in this direction. Consequently, usual practice is to scalp out fines and send only large material to the crusher.

STAGE CRUSHING—In anthracite particularly, stage crushing has been the practice for many years because of the nature of the raw product and also the size list produced.

To avoid a multiplicity of units, crushers are offered with a second stage of reduction built into them.

Crushers normally are built to handle iron, particularly if it is not too large. However, the better practice is to keep it out not only of crushers but of the entire plant circuit. If possible, therefore, magnetic removal equipment should be installed ahead of raw-coal crushers.

Rough Cleaning

PURPOSE: Quick removal of coarse rock and other impurities to reduce the burden on subsequent preparation units and also to permit higher efficiency in the removal process itself.

The major rough-cleaning methods are as follows:

1. **Picking table** receiving all the mine-run product.

2. **Scalping screen** followed by a picking table. This is a preferred system, since it removes the fines and thus facilitates picking, which may be either rough with the idea that final impurity removal will take place in mechanical cleaners, or may be final where the coarse coal is to be loaded without any further treatment.

3. **Rotary screen-type breaker**, which accomplishes both a reduction to a certain top size, depending upon the size of perforation, and rejects the hard rock—or at least that portion of it larger than the perforations. Normally, where rotary breakers are employed final cleaning is done in mechanical equipment.

4. **Conventional screen** to accomplish the same result as that attained with the rotary screen-type breaker. In one instance, a vibrating screen first removes the fines, after which the lower section functions to remove rock which rides over while the softer coal drops through.

5. **Roughing cleaners** to throw out the major part of the heavy material and prepare the feed for the final units. Fines may be bypassed around the roughing unit, while large lump usually is processed by hand picking. Preliminary breaking may also precede roughing with a mechanical cleaner. A further refinement is hand picking to remove coarse, heavy material, followed by breaking and roughing.

Rough cleaning by hand frequently precedes breaking, as noted in the previous section, and has the advantage, among others, of reducing the load on the breaking unit and reducing the output of fine sizes in the breaking operation by getting the hard, heavy rock out of the way.

Separate headhouses or roughing plants are being increasingly em-

ployed for preliminary breaking, rough cleaning, mine-rock disposal and raw-coal screening.

Raw-Coal Sizing

PURPOSE: Separation of the feed into the necessary fractions to permit picking, cleaning and other operations on the various fractions. In plants preparing by hand picking and cleaning, the raw-coal screen may also make the final sizes to be loaded.

The shaker screen, inclined at approximately 15 deg and with a crank or eccentric drive providing a stroke of around 6 in and a speed of 100 to 120 strokes per minute, is the common type of raw-coal sizing device. It is receiving increased competition, however, from vibrating screens, usually of the mechanical type.

A major difference between the two types of screens lies in the fact that the shaking unit also can be employed to convey and distribute the products, including provision for hand picking, as in plants preparing by hand picking and screening.

A second difference between the two types of screens is the fact that the vibrating type, though it cannot do conveying, provides higher capacity in a given space in many instances. Degradation with either depends upon type of coal, type of screen and method of operation.

The flexible-arm or Parrish-type screen, usually operating at 150 to 185 rpm, 5- or 6-in stroke, 2- to 5-deg slope, is another form of shaker. However, its major use is more for final sizing and dewatering, especially in the anthracite field, where it is widely used for this purpose. Laminated-plastic hangers are now used on such screens instead of boards (*Coal Age*, September, 1955, p 67). Advantages include longer life, no change in length and better screen action.

Screening Factors

In addition to inclination, speed and length of stroke (or amplitude with vibrators), some of the factors affecting screening results are:

1. Depth of bed. Since screening can be accomplished only when the smaller sizes work their way down to the plate, depth of bed, in conjunction with size of opening and square footage of screening surface, is a major factor. With large openings, depth of bed may be greater. With smaller openings, bed depth must be reduced or the area of screen surface must be increased. Time on the screen also is a factor, though the opportunities for increasing it are somewhat limited. Where it is increased degradation and breakage tend to increase with it.

2. Degradation. As previously noted, time is a factor in degradation. Narrow shakers also tend to increase degradation, and there is a major increase when more screen surface is provided than is necessary to accomplish the desired separation.

3. Wear. Heavy loads, coarse material and the possible presence of considerable rock are factors in wear on raw-coal screens. Among the answers for vibrating equipment is heavy alloy wire or alloy plate. On shakers, types of plate used to reduce wear include cast manganese.

Hand Picking

PURPOSES:

1. Impurity removal.

2. Improvement of appearance.

3. Production of a separate fuel grade.

From the standpoint of impurity removal, hand picking normally is effective only on coal 3 in or larger in size. Hand picking may also be employed to improve appearance by removing off-standard material.

Where bony by itself or in combination with good coal is fairly high in percentage, some operators use picking as a means of removing this material, which then is crushed and sold as a power-plant fuel.

Under reasonably good conditions, and where the impurity content is high, one picker can remove as high as 6 tph. Under average or poor conditions with a lower impurity content, production may drop to 1 to 2 tph.

Picking Equipment

Picking facilities include belt and apron conveyors, shaking tables and, occasionally, chain conveyors, the latter normally being employed only under special conditions and where the impurity problem is a minor one. All conveyor-type units lend themselves to combining the table with the loading boom.

The flat-topped apron conveyor and the shaking table best meet the major goal of removal of impurities without lifting or other handling beyond sliding the material removed to the discharge point. Other types of conveyors normally require skirtboards over the rollers or along the edges and thus necessitate lifting each piece to remove it.

The flat table may be a part of the shaking screen or may be separate. When separate, the table normally is sloped at about 5 deg and is operated at 150 to 160 rpm, 4- to 5-in stroke, crank or eccentric drive. Platform tables used in anthracite have a pitch of ⅜ to ¾ in in 12, with a 2-in stroke, 370 to 400 strokes per minute. The shaking table also lends itself readily to degradation removal by the installation of a screen section at the discharge end.

Some shaking tables have been equipped with partitions or deflection plates to further ease the load on the pickers by making it possible for them to do no more than push impurities out of the main stream to the center or pull them to the side. Refuse chutes should be equipped with bars to prevent passage of pieces large enough to block the refuse conveyor.

Washing

PURPOSE: Efficient removal of impurities in both coarse and fine sizes, and attainment of maximum product uniformity with a minimum of cost.

What actually happens in the separation of coal and impurities is a complex and to some extent unknown physical process. Particle size and shape are involved, as well as the resistance of the medium used to movement of particles through it, and the fact that coal is cleaned as a mass of particles, with consequent interference between free movement of particles within the cleaning medium.

HEAVY MEDIA—True or artificial solutions are increasing in use as separating media. An example of the true solution used for some years is calcium chloride, normally accompanied by a slight upward current. For the most part, the effect of solutions is obtained by suspending sand or magnetite in water. Mediums derived from the natural refuse also are used.

Since the ideal condition for separation of coal and heavier refuse is a still bath of the proper gravity, and since the true or artificial solutions come closer to this condition, the sharpness of separation is increased.

Other factors which may favor the use of a heavy medium include more-than-normal irregularity in quality and quantity of feed; a need for changing gravity from time to time; and operation at less than 1.45, where baths without upward currents theoretically offer the best conditions for a sharp separation, though capacity per square foot of area may be reduced.

GAGING SEPARATION DIFFICULTY—A good indication of the difficulty of separation is the amount of material in the raw feed that lies close

to the gravity of separation. In other words, the greater the percentage of near-gravity material, the more difficult, as a rule, the separation. A good indication of the efficiency of a cleaning operation is the quantity of misplaced material—coal in the reject and reject in the coal. To apply this measure, however, the inherent ability of the cleaner itself to separate coal and refuse must be known, since cleaners vary in their ability to achieve a given separation. Evaluation of this ability is a somewhat complex process, but methods of achieving it include those in "Evaluating Preparation Results," *Coal Age*, April 1950, p. 80.

In the main, however, if the washer is properly selected, is kept in adjustment, and is properly operated (see suggestions later in this section) it will provide the requisite separating efficiency. Basic in selection is detailed knowledge of the characteristics of the constituents of the feed.

Where it is evident that the problem may be difficult and the maximum in efficiency is desired, it may pay to wash sizeable tonnages in pilot equipment or actual going plants to check test results. The results of washing a new coal may also be predicted by mathematical or statistical methods, such as that described in "How to Predict Results of Washing a New Coal," *Coal Age*, June, 1952, p 98.

Washing Practice

Factors in the application and operation of washing equipment include the following:

SIZE SPREAD IN FEED—Certain types of washers require a rather small range in the size of the feed. Examples include the mechanical jig, classifier-type units, and certain washers using heavy media. The emphasis in design in recent years, however, has been toward equipment that will handle a rather large range of sizes—for example, the air-pulsated jig and the usual heavy-media equipment. The latter, incidentally, is now offered for handling a top size of feed ranging to 12 to 14 in.

Even where the washer is designed to take, say, all coal from 6 in down to zero, and can frequently do a good job on all the fractions in such a feed, some compromise must be made. Consequently, if tonnage is fairly high and a sharper separation is desired throughout, the practice is to install separate units for the coarse and fine fractions—for example, one for 6x1 or 4x1, and a second for 1x0. Where the equipment requires a closely sized feed, the only out is to install separate units for each fraction it is desired to clean.

BY-PASSING FINES—Fine coal, say ¼ in or less, may be by-passed around washing equipment for several reasons: (1) to keep it out of water and thus avoid the ensuing drying and handling complications, (2) to permit more efficient operation of washing equipment installed to handle a rather wide size range, and (3) because of the problems involved in mixing of fines with medium, such as, sand and magnetite. The fines may be subjected to further treatment in other equipment or, if both their quantity and ash content are not too great, may be mixed back into the washed coal.

UNIFORM FEED—A uniform feed, both in quantity per hour and in impurity content, adds measurably to the efficiency a washing unit can reach. The best method of attaining uniformity in quantity is the installation of some form of surge hopper or bin, plus a mechanical feeder, ahead of the washing unit. Attaining uniformity of impurity content is normally achieved by some form of blending equipment, as discussed previously in this Preparation Guidebook.

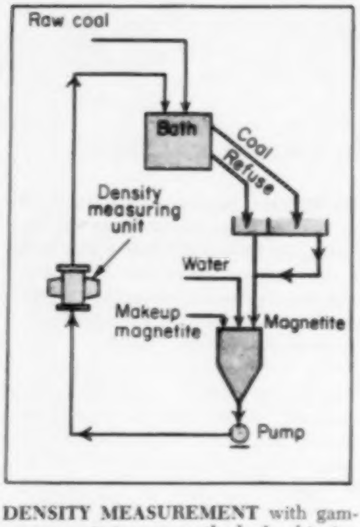
Feeding faults with jigs especially include the following:

1. **Overloading**—More tonnage than the unit can handle.
2. **Unbalanced feed**—More material to one side than to the other.
3. **Segregation**—One side or the other receives the bulk of the fines.
4. **Bad transverse distributing.**
5. **Interruptions**—Stopping and restarting a jig or other washer usually affects results materially.
6. **Fluctuations**—These, plus interruptions, are held by some authorities to warrant very substantial expenditures in raw- and clean-coal storage.
7. **Screen-plate troubles**—Loose plates or screens with holes can break up stratification and result in complete plugging of the cell with coal.

In view of the difficulties resulting from variations in feed, some preparation men now contend that coal should be washed without presizing to get away from the variations resulting from changes in the percentage of the various size fractions in the raw mine-run encountered when waiting each size fraction individually.

FEED CONDITIONING—Prewetting either in the feed chute or on special prewetting screens facilitates separation when the material reaches the washer, and consequently is finding increased use.

MEDIA CONDITIONING—Reclamation and treatment of the media used in heavy-media systems is necessary for at least two reasons: recovery of an expensive material that otherwise would be lost, and preservation of the proper gravity of the bath in the cleaning unit.



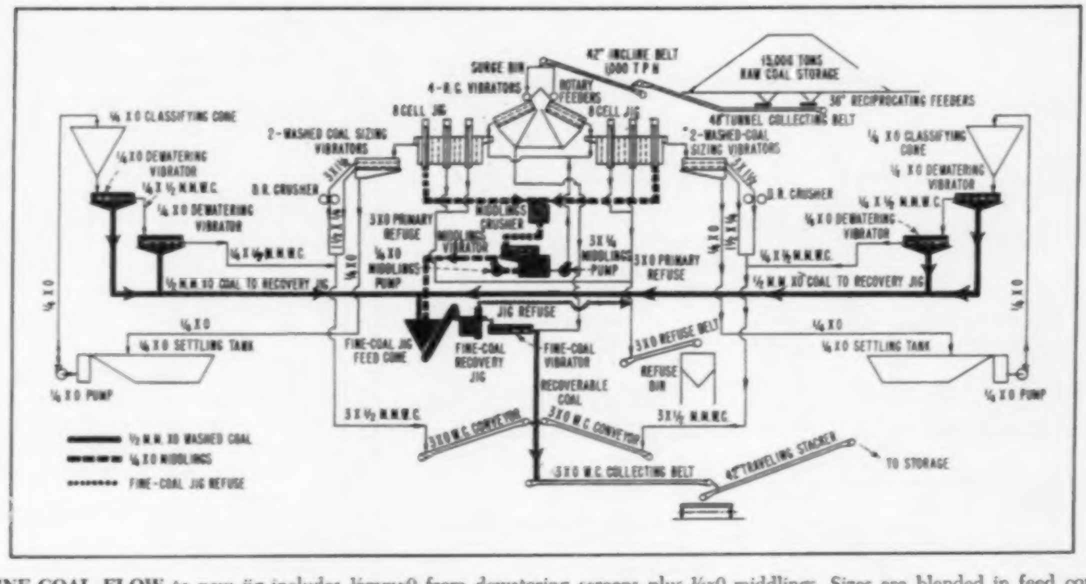
DENSITY MEASUREMENT with gamma-ray unit is new method of achieving bath uniformity with magnetite.

With magnetite, the simplest system consists of a magnetic separator to reclaim the material, previously magnetized to permit this to be done, from the water from the rinse and drain screens. This recovered material then is demagnetized and sent on to a thickener or densifier, from which it is returned to the separator bath.

Variations include use of thickener with overflow back to the rinse and drain screens for part of the water, and underflow to a magnetic separator discharging reclaimed medium to a densifier. Tailings go to a second magnetic separator, also receiving part of the rinse and drain water, with reclaimed magnetite to the densifier and tailings to waste.

Each of several heavy-medium separators in another plant is provided with two magnetic separators which return a concentrate of 2.2 sp gr and about 95% magnetic content directly to the medium circuit without further treatment. Tailings from all separators flow to a desliming sump. The underflow from the sump goes to two 12-in cyclones. Cyclone overflow is used as rinse water, while the underflow is reprocessed.

DENSITY CONTROL — Automatic control of bath density is provided for in equipment employed with certain new heavy-media cleaning units. At one installation (*Coal Age*, October, 1955, p 63), rinsing is done only on the lower sections of the drain and rinse screens, thus yielding heavy and dilute medium solutions, the former going to the recirculating sump and the latter to a magnetic separator delivering reclaimed medium to the same sump. Adjustment of the density of the medium is per-



FINE-COAL FLOW to new jig includes ½mmx0 from dewatering screens plus ¼x0 middlings. Sizes are blended in feed cone before passing to jig. Two jigs process 25 tph each of coal containing 25% ash.

formed by automatically adding water as required to the medium returned to the recirculating sump.

At another plant employing the dip-tube principle (*Coal Age*, May, 1956, p 69) the reclamation circuit involves magnetic separator, cyclones and a thickener immediately above the coal-cleaning equipment. Automatic valves release medium from the thickener as necessary to keep the gravity of the bath at the desired figure.

Gamma-ray equipment for gaging density of the magnetite solution as it flows also may be used for automatic control. The unit actuates high- and low-limit control switches and in turn magnetic feeders and valves to keep density within the desired limits.

CIRCUIT SIMPLIFICATION—Keeping the medium-recovery circuit as simple as possible to minimize capital investment has been the subject of considerable investigation. One plant, using sintering-machine flue dust, which eliminates grinding and recycling at the sintering plant, has simplified the recovery circuit by converting the thickener to a sump; eliminating the magnetizing and demagnetizing coils with no apparent change in the operation of the cleaners; using one drum-type separator per vessel, the product of which is high enough in concentration for delivery to the medium sump without the need of a densifier; and using the separator tailings as spray water on the feed prewetting screens.

One heavy-medium unit is followed by an unloading screen dropping water and magnetite into a sump directly underneath from which the medium is recirculated. Density of the bath is adjusted by adding thickened magnetite produced by a separator and derived from the cone and refuse rinsing operations.

DESILTING—Another form of conditioning is removing coal fines from the sand used in sand-flotation cones. The goal is continuous desilting, which is accomplished in one new installation by flowing the sand and water to a German-developed radial screen. The material is fed onto the sloping screens by four revolving arms, and as it flows across the screens is washed with fresh spray water. The oversize, or silt, flows by gravity to the silt sump, while the undersize, or sand and water mixture, is pumped back to the sand circuit.

Fine Coal Washing

With the increase in the use of machines, including the continuous type, the output of the finer sizes under, say, ¼ in, and the ultrafines under, say, 28M, is increasing. As a result, there has been a corresponding rise in special equipment for cleaning fines and ultrafines.

Installation of fine-coal cleaning equipment does not, of course, automatically provide a profit. For example, if 2% of the output was minus 28M but could be beneficated to make it acceptable, the cleaning would be feasible but the coal would wind up in 5 to 7 tons of water, which would have to be removed at a cost of up to \$3 per ton of water. Under such conditions, it manifestly would be cheaper to spend the money to mine fresh coal.

As a modification, if the output of, say, minus ⅛-in was 5 to 6% it might work out that the 1 to 2% of, say, minus 48M, could be discarded because of the extra cost of drying, making possible the recovery and cleaning and drying of the remainder at a profit.

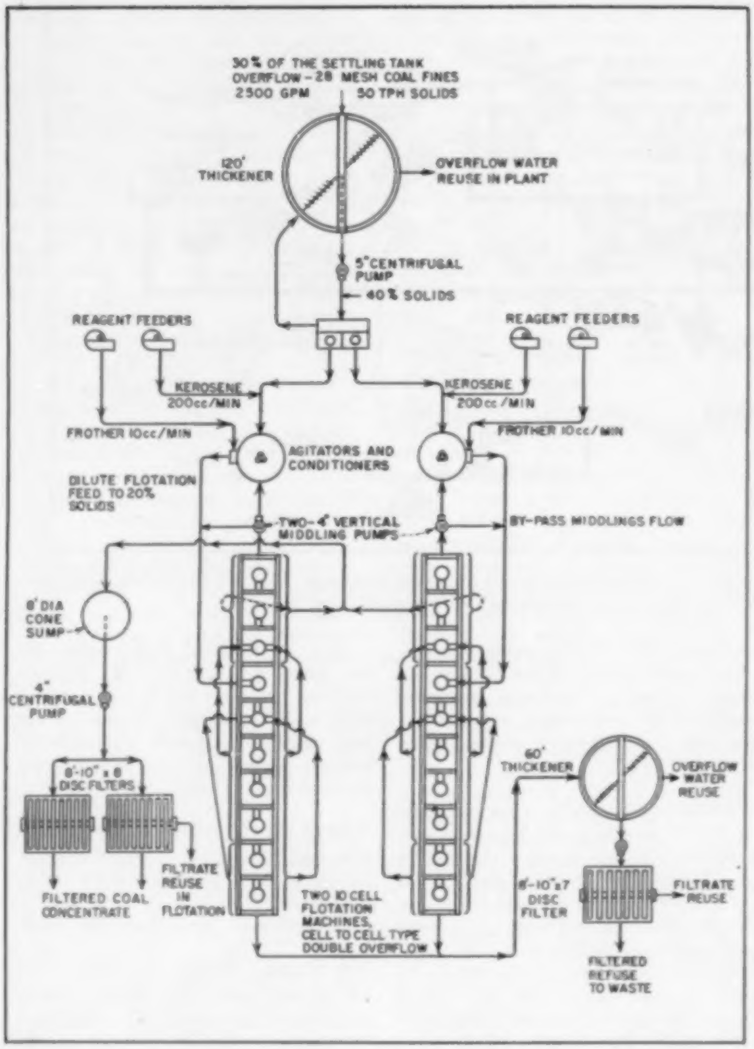
FINE-COAL UNITS — Equipment now used for coal from, say, ¾ in down to around 28M or 48M today includes the following:

1. **Continuous upward-current washers.**
2. **Washing tables,** including new double-deck units that double capacity in the same floor space. The importance of proper feeding is reflected in the number accompanied by feed distributors.
3. **Fine-coal launders.**
4. **Fine-coal jigs.** Such jigs have found rapidly increasing use.
5. **The heavy-medium cyclone,** which also can handle coarser material—up to 3/4 in. Feeds of up to 50 tph are possible with 20-in units. The coal is blended with magnetite in a pulping tank and then fed to the cyclone. The heavier-gravity material is discharged through the apex as underflow, and products are rinsed in the usual fashion, with the recovered and densified medium going back to the pulping tank.

Advantages cited for the cyclone include much less plant space, easy arrangement in multiple units separating at different gravities, no effect on sharpness of separation as a result of variations in load and raw-coal composition, low degradation, and ability to predetermine the separating gravity.

For coal under approximately 1/8 in,

in the raw feed frequently reduces efficiency in cleaning the fine sizes of coal in addition to adversely affecting dry-



FLOTATION SETUP for minus 28M coal using parallel flotation machines with middlings retreatment and following up by filtering both clean coal and also refuse fraction before final discharge to the bank.

or more usually under 28M, and containing material smaller than, say, 48M, the available equipment includes:

1. Flotation units, discussed in more detail later in this section.

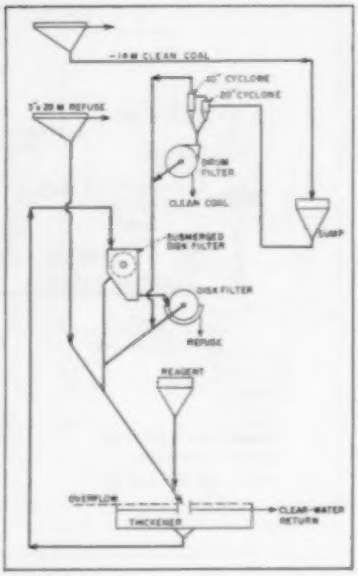
2. The bulk-oil process, using 5 to 10% of oil by weight and because of these large oil requirements considered more a possibility for metallurgical coal where part of the oil can be recovered in the coke-oven by-product fraction.

3. Fine-coal jigs, including those operating without an artificial bed, using plant refuse instead. One such unit handling ¾x0 turns out a product with an ash content of 8% when working on a feed of 25% ash. At other plants, as low as 7.5% ash has been realized from ⅜-mmx0 feeds containing up to 38.3% ash (*Coal Age*, October, 1957, p 94).

Classifiers and centrifuges might also be considered fine-coal cleaners on occasion. This results from rejection of the extreme-fine fraction which might carry the bulk of the ash.

Froth Flotation

As coal and refuse particles get smaller and smaller, their ability to move as desired through water or other washing medium becomes less and less until a point is reached where separation cannot be accomplished on the usual basis. The practical line of demarcation is somewhat indefinite, although the minimum so far suggested for heavy media, for example, is 1 mm, with ½ mm as a possibility. At that point, somewhere around 10M or less, a different principle of separation must be employed to get



CYCLONE DESLIMING is one feature of this fine-coal setup, which also includes flocculation in the thickener.

maximum efficiency with reasonable capacity.

Flotation achieves these goals. Facilities involved in flotation normally include a thickener or hydraulic classifier to size the feed, remove oversize, and so on; reagent feeders and conditioners where the reagent and the coal pulp are mixed and "conditioned"; and the flotation units themselves. The flowsheet also may be modified to include, for example, roughing cells preceding the final treating cells, retreatment units for a coal or primary tailing product from the primary bank of cells, or other modifications.

Two flowsheets showing, in one instance, the conventional setup for minus 28M coal, and in the other matte-type equipment for minus ¼, are reproduced in the accompanying illustrations (*Deco Trefoil*, May-June, 1957). In the 28M installation, retreatment is achieved by returning the discharge of certain cells to cells earlier in the series.

The minus ¼ installation is an example of a relatively simple flowsheet which accomplishes efficient recovery at a low ash content. The coarser fraction facilitates subsequent dewatering. Primary refuse is screened at 35M, and the plus 35 is retreated in a secondary flotation unit, followed by screening of the tailings and final treatment on a table. All the refuse is collected in a thickener for water reclamation. The underflow may be filtered if required or desired.

Desliming

Since leaving the extremely small sizes

and lack of uniformity in table feed

type units, usually termed "clones," offer

from the primary washer draw or a special middlings draw:

in the raw feed frequently reduces efficiency in cleaning the fine sizes of coal in addition to adversely affecting drying the trend today is to deslime or desilt prior to cleaning or drying. Desliming or desilting equipment includes cyclones, hydraulic classifiers, hydroseparators and bowl-type desilters. The latter, as installed at one new plant, consist of a flat-bottom thickener tank with revolving plows to move the settled solids out to the periphery, where they are discharged to a standard rake classifier through a segment cut out of the bottom of the thickener tank. For a summary of how this equipment is employed, see "Thickening and Desliming."

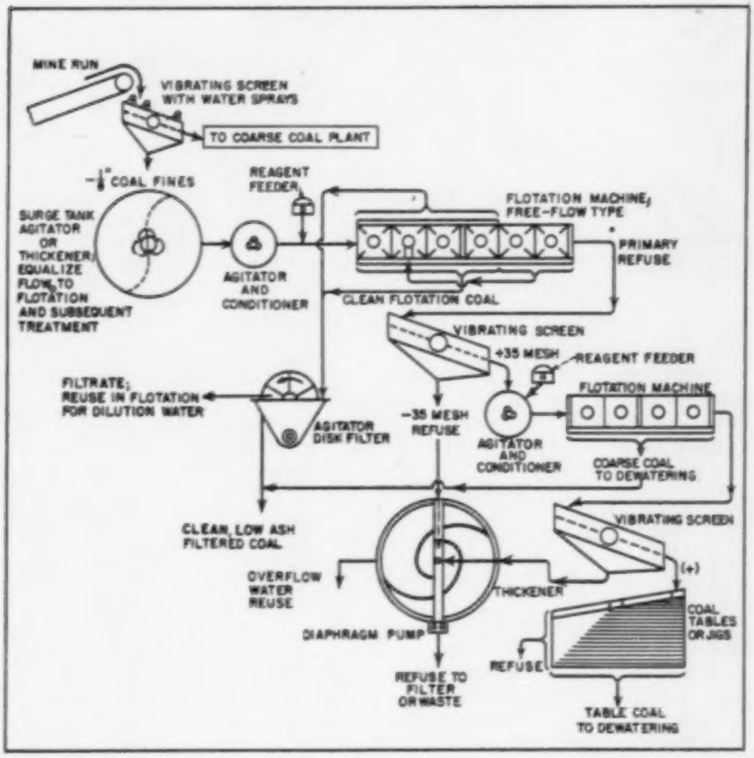
Desliming with other types of equipment include the following examples:

Classifier desliming silt prior to tabling and flotation (*Coal Age*, May, 1955, p 78).

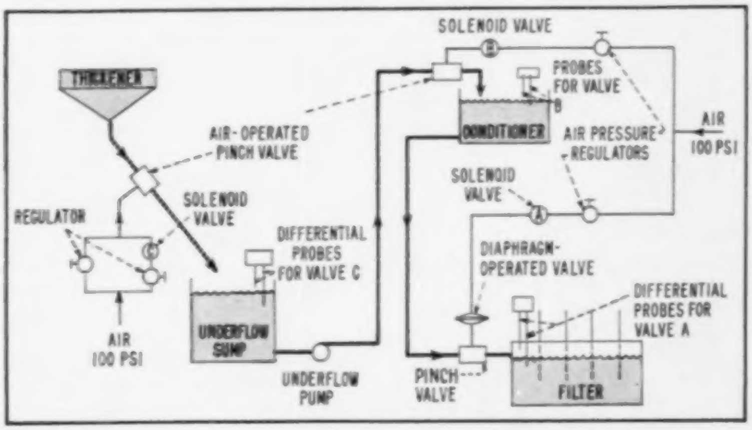
Hydroseparator removing minus fines from No. 5 buckwheat feed to flotation plant (*Coal Age*, November, 1954, p 98). The hydroseparator is followed by a classifying conditioner using a conical section and baffle plate to concentrate high-ash fines, which are removed by an air lift.

Plus 48M overflow from elevator boot in launder plant to thickener acting as classifier, with overflow to a second smaller thickener for flocculation and pumping to slime-disposal pond. Second circuit involves drag tank from which 150M overflow goes to thickener. Settled solids go to two vacuum filters. Cake goes to refuse.

Slurry to 14-in cyclones, overflow to 3-in cyclones, underflow from both to flotation cells; clean coal to vacuum filter, filtrate returned to cell circuit; overflow from small cyclones with flotation tailings to thickener after flocculation; thickener overflow recycled; underflow to vacuum filter with filtrate recycled and cake to refuse. Benefits include higher coal quality, complete control of circulating water density and viscosity, closed circuit, and elimination, except for emergencies, of sludge pond formerly required for weekly bleeding.



COAL UP TO ⅛ IN is treated in this flotation setup using machines designed for the service. Clean coal, refuse are filtered and thickened, and provision is made for final tabling or jigging of tailings.



AUTOMATIC FEED-FLOW CONTROL for filters employs a combination of probes and valves to achieve uniformity in results.

Air Cleaning

PURPOSE: Elimination of water and drying complications in producing low-impurity uniform-quality coal.

The basis of cleaning with air is substantially the same as for cleaning with water or other mediums (see preceding section). Air, however, eliminates or reduces the drying problem, although it involves a dust-handling problem similar to the water-handling and clarification problem involved in wet washing.

High-ash and high-sulphur impurities are removed completely but there is practically no bone separation with air as the medium. The lower limit of cleaning with the most-used type of unit today is about 48M. There is no improvement in ash below this size but at the same time all the finer coal is available for mixing with the clean coal, meaning 100% recovery without the sludge and dewatering problems accompanying wet washing.

Air cleaners normally operate on a fairly closely sized feed and, as with water, the feed should be uniform in quantity and as nearly uniform in impurity content as possible. Moisture variations are particularly troublesome in air-cleaner operation, in addition to the effect—usually less severe—of high surface moistures.

PREDRYING — Present practice in eliminating the effects of high moisture

Another form of salvage, widely practiced in anthracite and to a limited extent in bituminous, is reworking con-

be excessive if good screening is desired, and the smaller the opening the less the bed thickness should be if ex-

Among the goals are: (1) increased screen capacity, (2) reduced blinding and (3) less breakage with friable coals.

and lack of uniformity in table feed is to predrying, and a number of plants recently built include predrying equipment of the heat type. At the same time, if total moisture in the mine product normally is high, the operator gains the sales advantage of a minimum moisture content in the shipped product. Increased moisture in the raw product, incidentally, reflects the growing use of water at the face.

To simplify the installation and eliminate duplication of equipment to supply air for drying and also for cleaning, one installation employs the drying air for cleaning as well. In this installation, a heat exchanger is employed to avoid passing the products of combustion through the cloth dust separator.

The majority of the air cleaners installed today operate on coal ⅜ in or less in size, though larger coal is treated. From the standpoint of the drying problem, washed coal over about ¼ or ⅜ in may be dewatered sufficiently for acceptance without special equipment—at least in many instances—which is in part the reasoning leading to the installation of combination wet and dry plants. And if mine conditions or mining practice make drying of fines desirable, it may be accomplished to the advantage of the air-cleaning process by predrying as previously noted. Normally, 2 to 2½% surface moisture in ⅜- or ¼-in coal is about ideal.

Most air cleaners now installed are three-product machines, and thus normally provide a middlings product for retreatment. The goal in this middlings production and retreatment is maximum efficiency in separation with minimum loss of coal values. Dedusting to remove up to 50% or more of the fines—usually 48M—adds significantly to normal air-cleaning efficiency.

Dust Collection

Every air-cleaning plant should be provided with an adequate and efficient dust-collecting system—not only for better operation but to prevent the emission of large volumes of dust into the air. Equipment for dust collection includes the following:

1. **Large expansion chambers** into which the dust-laden air is routed to permit settlement. However, such chambers can trap only the larger particles. Smaller baffled units are employed, however, for scalping ahead of other equipment such as cloth collectors.

2. **Cyclone collectors.** These centrifugal units are a popular means of removing dust from air. Since single units handling large volumes are less efficient because of reduced air velocity, multiple and tandem units are offered, raising separation from, say, 85 to 95%, up to 98%.

3. **Turbo-centrifugal collectors.** Turbo-type units, usually termed "clones," offer the advantage of smaller size as a general rule. Like the standard cyclones, they are relatively inexpensive to buy, are easy to operate and are low-maintenance units.

Even at 98% separating efficiency, the quantity of very fine dust that can still escape to the atmosphere can run up to several tons per day. To trap the most of this remaining fine dust, cloth or bag-type and wet-type collectors are employed.

CLOTH COLLECTORS — Of the cloth-type collectors, the bag type was one of the first to be installed at coal-cleaning plants, normally with a shaking device to remove the accumulated dust. A more recent development is the cloth-screen collector, which provides larger capacity per unit of space occupied, is easier to inspect and maintain, and is provided with an improved cloth-shaking device. To prevent interruptions while the dust is being shaken off the units, dual-unit, or continuous cloth collectors may be installed, the air being directed alternately from one to the other.

Exhaust operation of dry-type equipment keeps the dust within the ducts and equipment in case there are leaks. Acid, abrasion and the like are factors to be considered.

WET COLLECTORS—Wet-type collectors include the tumbler; a combination of turbo-centrifugal unit and water sprays; and the hydrostatic. All have the advantage of high capacity in relatively small space, in addition to a high separating efficiency as a result of the use of water, particularly in the tumbler and hydrostatic units, where the dust-laden air is passed through a water bath. Both units have no moving parts.

A new unit in the form of a cylinder comprises a wet-impingement screen, turning vanes, chambers in the walls to receive the air and water particles thrown out by centrifugal force, straightening vanes and an exhaust fan. One-tenth to one-twentieth the size with high efficiency is among the claimed advantages.

Retreatment

PURPOSE: Increase the ability of the washer to do a sharp separating job by relieving it of part of the load, particularly where the percentage of near-gravity material is high and consequently the cleaning problem is more difficult.

Steps in the retreatment of coarse coal are as follows, starting with a product from the primary washer draw or a special middlings draw:

1. **Preliminary screening** of the product at 2 in or other limit.
2. **Crushing of the oversize** to the screening limit to release the impurities.
3. **Recirculation of the crushed product** to the washer or to a separate retreatment unit. Separate retreatment units are employed where several units handle primary cleaning or where, even after crushing, the recirculated product contains considerable material close to the washing gravity.

With the smaller sizes, particularly less than, say about ¼ in, where crushing is often less effective as a means of releasing the coal values, the entire draw product may be recirculated or retreated in a separate unit. This is particularly true in aircleaning coal under approximately ⅜ in.

The value of this method of enhancing cleaning efficiency and reducing coal loss is evidenced by the increasing use of separators designed to produce three products: clean coal, middlings and refuse. This has been particularly evident in cleaners of the heavy-media type.

Salvage

PURPOSES:

Reclamation of coal that otherwise would be lost because it never gets to the preparation plant, or because the preparation system is set up to reject it without an opportunity to get it back.

Recovery of coal from primary washer rejects left in because of a desire to get sharper separation or because of washer overloading resulting from a change in coal and refuse character or the need for more tonnage.

Examples of salvage operations include the following:

1. **Crushing and washing of pickings,** either in regular or special units to save coal values.
2. **Picking out, crushing and loading separately** for steam coal a bony product that might otherwise go to refuse.
3. **Processing of roof brushings, track cleanings** and the like to recover a regular or a steam-coal product. Normally, the production of such material should be sizable to warrant separate facilities.

Recovery from primary washer reject also, as a rule, involves preliminary screening to take out fines and crushing to release interbedded material, although the reject may be treated as it comes from the primary units. The latter, however, usually is less efficient and does not give as good a recovery.

Another form of salvage, widely practiced in anthracite and to a limited extent in bituminous, is reworking contents of old refuse banks and silt ponds or dumps.

Salvage operations ordinarily are carried on with conventional screening, crushing and cleaning equipment. Exceptions include the use of rock-type screens and crushers, and extra-large draws on cleaners where mine material or pickings containing large percentages of rock are processed. One highly desirable characteristic of a salvage cleaner is ability to handle a wide range of feed, both in refuse content and in quantity, since there is less opportunity for stability in either rate or characteristics.

Clean-Coal Sizing

PURPOSE: Separation of the product of cleaning or other processing operations into the final or semi-final size group for loading, or for loading plus additional treatment of a certain size fraction, discussed in later sections of this Guidebook.

Clean-coal sizing, or classification, is handled by both shaker and vibrating equipment, the latter having made substantial gains in this field as well as in the field of raw-coal sizing. Certain factors involved in clean-coal sizing are substantially similar to those in raw-coal sizing. In addition, accuracy becomes vital, not only because of its effect on the buyer but also because inaccuracy can materially affect realization by putting larger sizes into smaller. This in turn brings in questions of plate and cloth wear, blinding, and so on. Also, screening should be done to keep degradation in the process to a minimum.

Shakers and vibrators are the old-reliables in clean-coal as well as raw-coal screening. Among the new types finding application in the U.S. are the radial and the upright curved-deck screens.

Accuracy Factors

Aside from moisture and blinding, accuracy involves time the coal is on the screen surface, and also cloth or plate wear. Time on the screen brings in the question of breakage, or degradation, which increases with increased screening time, though as in anthracite, the hardness of the coal may permit a longer retention time without increase in breakage.

Other things being equal, sufficient time must be provided to permit the smaller sizes to work down and be separated out, and in turn this brings in the question of bed thickness. It should not be excessive if good screening is desired, and the smaller the opening the less the bed thickness should be if excessive length of screen is to be avoided. Where one of the products is screenings and the feed to the unit includes all sizes up to lump, depth of bed should not be more than 4 to 6 in, and screening efficiency and capacity may be increased by placing a large-hole relief screen on the slack section.

SCREENING EASE – The relative ease or difficulty of screening a certain feed at a certain size, which in turn is one measure of the screen area necessary for accurate separation, reflects in the main the quantity of near-opening material in the feed. If there is a substantial percentage of material at or slightly larger than the opening size, particles smaller than opening size find it more difficult to work down through the bed of near-opening material, and also there is a greater chance that particles only slightly undersize will be carried beyond the screening surface before they have an opportunity to go through. The difficulty increases as the size at which screening takes place decreases.

Screen Wear

Plate, cloth and wire wear reflect load, screening time, abrasive nature of the material, corrosion if the water is acid, and the material used in the screen. Where plain-steel plate is employed, increasing the thickness is one way of offsetting the effects of wear but brings a significant decrease in screening efficiency. Consequently, operators turn to bronze and alloy steels, with stainless coming rapidly to the front in recent years for the smaller sizes. However, as a general rule, stainless life must be 10 times plain steel life to justify its use for wear resistance alone, and therefore bronze or other alloys are favored for heavy plate. With round-rod or wire screens, or with special-profile bars, wear is largely on the top and consequently the period of reasonable accuracy is materially lengthened.

Small-opening punched plate must be relatively thin, both to facilitate the punching operation and because excessive thickness, as previously noted, affects screening efficiency. Consequently, additional support is required to prevent sag and wear. Bars under the plates are the preferred method. An alternative is the Perister-tread screen—a stepped-type unit in which the risers provide the extra support while the screening is done on the treads. Bars or other supports also are installed under the cloth on vibrating screens.

SPECIAL SCREEN OPENINGS – Elongated openings frequently are employed instead of round or square. Among the goals are: (1) increased screen capacity, (2) reduced blinding and (3) less breakage with friable coals. However, replacing conventional screens with long-opening units, with no change in the effective width of opening, normally increases the size of the through product.

A special form of screen is the lip type, usually with a greater width at the lower end of each opening. It provides a tumbling effect and this together with the type of opening, normally results in an increase in capacity of up to double or more. At some plants this characteristic has resulted in installation of lip screens to offset a condition of chronic overload. Incidentally, overloading severely affects screening efficiency. For maximum accuracy, feeders or other devices should be provided to insure uniformity in rate of feed to screens.

Use of elongated, lip and similar screens brings in the factor of separation by shape as well as by size. Consequently, the products are quite different in character, with considerably more flats in the underproduct with the elongated-opening units.

Blinding—Cause and Elimination

Blinding in coal screening occurs with all sizes but is particularly annoying and most affects efficiency with the smaller material. Blinding reflects in the main the percentage of particles near the size of the screen opening and especially, as the size of the coal decreases, surface moisture.

Additional factors tending to increase blinding include overloading and the presence of clay and shale mud. As a rough rule, a surface moisture of 6% will result in complete or nearly complete blinding at separations of ¼ in or smaller. At 2% or less, little or no blinding occurs.

Aside from blinding, moisture also tends to increase the inaccuracy of screening by causing small particles to stick to larger pieces. Where washing is done, one of the functions of sprays on classifying screens, in addition to opening up and agitating the bed to facilitate separation, is washing the fines off the large pieces and through the screen.

The building up of a film of moisture and packed fine material is held to be the major cause of blinding in fine-coal screening. Time is a second major factor. Rust and corrosion with plain steel also especially after the screen has been idle can cause major blinding difficulties, for a time.

Electrical heating is rapidly growing as a means of preventing blinding of screen cloth. Other methods applying to cloth, plate or both, include:

1. **Alloy metals** which resist wetting and film buildup.

2. **Use of plate,** wire and cloth impervious to or less subject to rusting and corrosion.

3. **Use of large openings,** though this brings in the risk of throwing more oversize into the through product.

4. **More screen area** or a lower feeding rate with higher moisture.

More fundamental, perhaps, are mixing and blending to achieve uniform surface moisture or predrying of moist or wet material.

SCREEN HEATING — Heating cloth electrically is a common means of preventing blinding. Most screen manufacturers now offer designs applicable to practically all types of screens. In addition to eliminating blinding and its attendant effects, including the necessity of increasing screen opening, heating also offers two other advantages.

1. **Increased screen output**—up to 50% or more.

2. **Longer screen life**—up to 4 or 5 times in some instances. Also, some operators have found that they can get increased life with smaller wire and less costly cloth.

Heating, however, like other methods of preventing blinding, will not prevent wedging of near-size particles in the cloth nor clogging when the depth of the bed on the screen is greater than recommended practice.

Degradation Removal

Screening out of small pieces resulting from breakage in processing, sometimes called rescreening, can take place at convenient points in the operation. Usually, however, it is done immediately ahead of the loading boom or chute, generally by a separate section of screen in the sizing shaker or in the chute leading to the boom.

Dewatering, Drying

PURPOSES:

1. Reduction of moisture in the final product and enhancing the benefit to the consumer, particularly in the industrial category, by raising Btu content, reducing freight cost, or better fitting the coal for such uses as the production of metallurgical coke.

2. Elimination of freezing difficulties.

3. Preparing the coal, by such methods as predrying, for added efficiency in screening, air cleaning and the like, while at the same time securing Benefits 1 and 2.

Because the surface area on which moisture can collect increases rapidly with reduction in size, dewatering presents a greater problem with fines. As a rough rule, natural drainage will reduce the moisture on coal above ½ in and perhaps down to ¼ in to a point where there will be little or no freezing except in very severe climates. However, it may be desirable to reduce the moisture still further for the reasons set out at the start of this section. Below ½ or ¼ in, in the absence of some other form of treatment, freeze prevention requires specific dewatering methods and equipment.

Natural Drainage

Equipment employed in dewatering by natural drainage includes hoppers and bins; inclined and horizontal conveyors with screens in the bottom; perforated bucket elevators; and fixed screens. Fixed screens in flumes from washers to classifying screens, in fact, are widely used for unloading a large part of the water.

The fixed-screen principle for unloading or reducing excess water has been developed into special types of units both here and abroad. The launder screen recently developed for anthracite is made by placing 6-in-high partitions every 6 in along a chute or launder pitched at ¾ to 1¼ in per foot. Screen cloth is tacked over the compartments, which are drilled in the bottom to receive pipe bushings. Only a small percentage of the water and fines is removed in each compartment, resulting in more-even water distribution over the entire screen surface. Also, the bed is maintained in fluid condition, resulting in high screening efficiency.

A combination of "partitioned" and "radial" screens is used abroad and is now offered in the United States for preliminary dewatering of minus ¼-in coal prior to centrifuging (*Coal Age*, September, 1953, p 95; September, 1956, p 78).

For coal larger than ¼ or ½ in, dewatering by natural drainage is quick and complete, and the product, as noted, normally will not freeze unless the cold is severe and lasting. Where the finer sizes are involved and freezing is a consideration, the problem becomes more difficult. However, natural drainage of coal as fine as 1/16 in and 28M to surface moistures of 10 to 12% is being achieved with flotation coal.

Mechanical Dewatering

Omitting such processes as thickening and the like (see later section in this Guidebook), mechanical dewatering is done by screens, centrifuges and various forms of filters, the latter including the high-frequency electrically actuated vibrating type. With all, the dewatering process, as with fixed screens, normally involves producing a through product which must be loaded wet, discarded or treated by other means. Also, the overproduct, depending on size, and other factors, may be further processed in other types of equipment.

SHAKER SCREENS — Conventional shakers of course accomplish dewatering, but when dewatering is the specific goal the tendency is to go to special screens, usually flexible-board-hung or supported and operated at speeds of 150 to 400 rpm, with short throws of around 1 in. Anthracite shakers for both dewatering and sizing tend to operate at nearly conventional speed and stroke but with only a slight inclination, usually ¾ in per foot. For dewatering only, the speed is increased to 200 to 400 rpm and the throw is cut to 1 to 1½ in, especially for the smaller buckwheats.

Plate or cloth may be used in dewatering the larger sizes, and plate also is employed for a substantial portion of the smaller sizes in anthracite. In bituminous, however, when dewatering at, say, 28M, the tendency is to use cloth, rod or wedge wire.

When used for dewatering, the shaker-type screen normally will reduce the surface moisture of sizes above approximately ¼ or ⅜ to 5% or less. When dewatering smaller sizes at, say, ½ mm or 28 M, surface moistures of as low as 3% have been obtained, but the range usually is 5 to 10% and higher.

VIBRATING SCREENS—When used within their limitations, vibrating screens provide real advantages in the field of dewatering. Initial, operating and maintenance costs are low, and a high removal of solids from wash water is achieved with a minimum of effort. Since operation in a nearly horizontal position is necessary, it usually is desirable to have a high operating speed and a stroke at an acute angle with the screen deck to facilitate the conveying action, which normally is slightly uphill.

Width and length of screen should be selected for proper handling of the expected quantities of water and solids. Openings as narrow as ⅛ mm can be employed in some instances but the usual lower limit is ¼ mm. Special attention to keeping the width narrow enough to maintain a bed at all times is required. Dams in the center and at the discharge end help both in maintaining a bed and in promoting water removal through longer retention of the coal on the screen. However, dams should not be high enough to result in excessive bed thickness.

The bulk of the water should be removed on the first half of the screen for best results, and a bed of the requisite thickness should be formed as soon as possible to prevent excessive loss of the fine sizes. Unloading of as much

water as possible before the coal is placed on the screen helps, and if fine sizes from some other unit are added they should be placed gently on top of the bed after it is formed. Size distribution of the primary feed should be such that it will form a bed.

Dewatering results reflect size of coal handled. Where the average size of the feed is around 5/16 in, a surface moisture of 5% normally can be attained, and in many instances much less. Final moisture increases with reduction in size up to 25% or more with, say, 28 or 48M material.

CENTRIFUGAL SCREENS — Now being offered for both dry screening and dewatering of the smaller sizes, the centrifugal screen provides results down to as low as 2 to 3% for coal approximately ¼ in in size in some instances, and normally around 5%.

CENTRIFUGAL DRIERS — Equipment of the centrifugal type commonly used in coal preparation includes the following:

1. **Vertical units with transporting facilities.** Positive transport results in equal centrifugal action regardless of size consist and prescreening is not necessary. Feeds of up to 20 to 45% surface moisture can be handled. If the percentage of extreme fines is not unduly high the unit will cut moisture in a ⅜ or ¼ x 0 feed to as low as 5 to 6%, with usually over 90% recovery.

2. **Vertical units without transporting facilities,** using water or vertical vibration to move the coal. As a result of absence of a basket, minimum screen-plate thickness is about 3/32 in, limiting perforations to about this size. Coal under around 28M usually should be removed from the feed. On ⅜ or ¼x28M, moistures of 5 to 6% can be attained with recoveries of over 75 to 80% as a rule.

3. **Horizontal solid-bowl type** —simplest of the three but less flexible. Recovery of ⅜ or ¼x0 is 95% or better. Final moistures are somewhat higher than with other types in many instances, though comparable results have been achieved with desliming.

In terms of actual water removed the centrifuge ranks high as a low-cost device, providing a total cost of between 5 and 10c per ton of cake. Degradation in operation must be expected. Means of reducing it include:

1. **Introducing the coal evenly** around the top of the basket at approximately surface speed, in turn a function of the number of vanes in the receiving element of the centrifuge.

2. **Clearance** no greater than particle size in machines with transporting facilities.

3. **Use of rubber skirts** instead of metal or concrete wear rings at the bottom to reduce discharge impact.

FACTORS AFFECTING CENTRIFUGAL RESULTS—The size of the fines fraction affects the results of centrifuging in much the same way as it affects the results of other forms of drying. As an example, solid-bowl units have produced surface moistures of 1 to 13% where the slimes have been included in the feed. In another plant, the same unit, with 60% of the minus 200M material removed from the feed, achieved a cake moisture of around 6%.

Maintenance also has a major bearing on the results of centrifuging. Proportions and clearances are carefully designed for maximum efficiency. Frequent maintenance, rather than letting renewable parts run to destruction keeps the moisture in the output at a minimum and thus increases acceptability without further treatment or makes the cost of subsequent thermal drying appreciably less.

FILTERS — With the increase in pressure to reduce stream pollution, and also as a result of the growing use of other types of mechanical dewatering equipment producing effluents containing fine material, there is an increased trend toward the installation of filters of the continuous-vacuum type. As a corollary, a solid-bowl centrifuge especially designed for the service, known as a "polisher," is used for the same purpose.

Among the vacuum filters the drum type, and especially those with top-feed reservoirs, can handle coarser solids but require considerably more floor space.

FINAL MOISTURES — With the vacuum type, flocculation of the fine-coal particles by means of caustic starch or some other agent (see discussion later in this Preparation Guidebook) increases filter capacity and reduces moisture in the final cake. However, some experience abroad has indicated that starch-type flocculants can result in difficulties in flotation where the filter effluent is recirculated. For a report on how flocculation increases filter capacity and how to select a flocculant, see *Coal Age*, December, 1957, p 74.

Final surface moisture of the filter product is held to reflect largely the moisture in the feed, the percentage of minus 200 to 325M material and the ash content of the dried product, though feed moisture apparently is less of an influence than the other two factors. Depending upon percentage of fines and ash, surface moisture in the product ranges down to as low as 15% and up to approximately 30%, with some exceptions both above and below. For a complete discussion of selecting and operating disk-type filters, including factors affecting filtration rate and moisture removal, see *Coal Age*, January, 1955, p 76.

AUTOMATIC FEED CONTROL — The accompanying diagram shows the automatic feed-flow control used at one plant to get a full cake at all times, prevent recirculation of solids, relieve the operator for other duties 90% of the time, and attain uniform cake moisture (*Coal Age*, October, 1957, p 106). Differential probes in the underflow sump, conditioner and filter tub control valves which in turn control slurry flow.

Thickening and Desliming

Since large volumes of water complicate the final drying job—whether in mechanical or heat equipment—and since very fine material decreases the capacity and efficiency of both mechanical and thermal units, the trend today is toward thickening or desliming, or both, in advance of drying, as well as in washing, as noted previously.

THICKENING—Reducing the water load on the final drying units may be done by relatively simple means, common ones being fixed sieves or mechanical or electrical screens—usually both—ahead of the drying unit. For even greater water removal, plus also desliming, the equipment that may be employed includes drag tanks, thickeners and cyclones, which may be preceded—and usually are—by fixed sieves and operating screens for unloading.

The cyclone has the advantage of low cost and high flexibility. The settling tank also has the advantage of relatively low cost and simplicity but the degree of thickening may not be as great. Sedimentation in relatively still water is perhaps the ultimate in thickening, and is the province of the usual circular thickener. Although their first cost is relatively high, maintenance and operating costs are almost negligible and they produce clear water for reuse. To speed settling or to take care of conditions approaching colloidal suspension, flocculation may be employed. Starch is still considered the most satisfactory medium, though, as previously noted, it may result in trouble if the water is recirclulated to flotation circuits. This trouble, however, is not encountered with synthetics, which are finding increasing use.

THICKENING SYSTEMS — Settling tanks frequently precede centrifuges and other types of dewatering equipment. Examples of thickening before drying with the settling tank and other types of units include the following:

1. **Drag tank** employed to recover ¼x0, with 50-ft thickner for minus 60M fines.

2. Settling tanks and 14- and 3-in cyclones used to clarify and recover coal. In addition, by bleeding 98% of the minus 200M, which is impounded, the system's solids content is kept constant.

3. Silt from tables and flotation equipment, at a rate of 102 tph in 1,440 gpm of water to eight 14-in cyclones; thickened cyclone underflow (101 tph maximum in 900 gpm) to three solid-bowl centrifuges (*Coal Age*, May, 1955, p 78). Desliming at this plant, incidentally (see flowsheet), is done ahead of the cleaning units.

4. Fine coal (¼ x 0) to drag-conveyor settling tank, with underflow to centrifugal dryer, overflow back to wash box and effluent from top of tank to settling pond (*Coal Age*, June, 1955, p 68).

5. Thickening prior to filtering at another plant is handled by a battery of three 20-in cyclones in series with eight 14-in cyclones (*Coal Age*, December, 1955, p 70). The cyclones remove approximately 150M from a 28M feed, and handle approximately 1,800 gpm with a pressure of 35 psi on the outlet side of the 14-in units. The 14x150M cyclone product than goes to two top-feed-reservoir filters reducing moisture to approximately 18%. Cake is stored in a special tub-shaped bin equipped with a boom-type scraper conveyor. The bottom of the bin is shaped so that when the conveyor is lowered onto it the fines may be removed completely. Other drying equipment in the plant includes centrifuges for ⅜x0 and thermal equipment handling both centrifuge and filter products, reducing the moisture to approximately 3⅜%. Feed moisture is approximately 9%.

6. Cyclone underflows flocculated and delivered to thickener; thickener overflow to raw-coal shaker or pond; underflow to refuse filter; thickener also receives product of filtrate pumps (*Coal Age*, October, 1957, p 76; see also flowsheet with "Water Handling" section).

DESLIMING—Removal of very fine material prior to further drying may be done as the first step in the fine-coal processing cycle, or directly before the material to be dried goes into said drier. Removing clay limes, as an example, ahead of froth flotation keeps reagent consumption low.

Desliming before processing at one new plant is done in two bowl-type desilters. The desilters overflow minus 100M, approximately 80% of which is minus 200M. The coal then goes to the table plant, which is followed by four solid-bowl centrifugal filters, with a fifth as a spare. Filter effluent is returned to the clarified-water circuit (*Coal Age*, September, 1956, p 78). The final dewatering step at this plant is performed by thermal driers reducing moisture to approximately 3%.

Cyclone desliming is included in the accompanying flowsheet of a clarification setup also involving flocculation (J. M. Vonfeld, AIME, February, 1956). The 1⅛ x 14M clean coal is screened at 14M, with the minus 14M being pumped to 20-in cyclones. The 20-in cyclone overflow then is deslimed in the 10-in units. Underflow from both is filtered in a top-feed drum unit and loaded with the clean coal. Effluent from the small cyclones and drum filter is sent to the thickener with minus 28M refuse, added to improve filtration of the thickener underflow.

The thickener feed is treated with causticized corn starch to increase solids settling rate and improve clarity of overflow water. The thickener underflow goes to a submerged disk filter whose purpose is to permit withdrawal of the underflow with a fairly low solids content without influencing the operation of the final disk unit. This final filter is able to maintain a relatively thick, dry cake—disposed of with the coarse refuse. There is no bleed, and the overflow from the thickener is returned to the table plant as dressing water. It is clear, facilitating observance of table operation.

At another recent plant (*Coal Age*, September 1957, p 76) desliming ahead of centrifuges is accomplished by a horizontal vibrator with ⅛-min screen receiving ¼ x 0 from a setting tank. Screen underflow returns to the tank.

WARM-WATER PROCESSING—Experience at a number of plants indicates that the efficiency of mechanical dewatering by screens, centrifuges, etc., is higher in summer when the water temperature is up. In other words, the water is easier to shake or spin off. Advantage is taken of this fact at one plant (*Coal Age*, December, 1955, p 70), where dust is removed from the drier exhaust by a combination of cyclone collectors, and water sprays are used to cut down the speed and volume of the first exhaust to the atmosphere. Four thermal driers each exhaust 50,000 cfm at 200 to 250 F. The exhaust carries with it 14Mx0. Two cyclones are provided for each of the four drier exhausts, after which the gases go to a concrete duct leading to a silo chimney.

Sprays in the concrete duct reduce gas temperature from approximately 180 down to 110 F. The warmed water, with its temperature raised about 45 F, is returned to the fine-coal washing circuit, raising its temperature by up to 13 F in winter. This warmer washing water and resulting warmer coal facilitates mechanical dewatering, apparently by reducing surface tension.

Heat Drying

Heat drying is about the only way to get surface moistures of as low as 2 to 3% consistently, particularly with the finer sizes.

DRIER TYPES—Types of heat driers used in coal mining are:

1. Rotary, with either inner and outer shells, or an outer shell with lifting vanes inside.

2. Reciprocating screen, which also acts as the carrying medium. In most instances, the gas is pulled down through the bed and the drying action is of two types; evaporation and, to some extent, mechanical as a result of the screening action and the scrubbing action of the gas. When the gas flow is interrupted by an appropriate valve and then is resumed, squeezing also takes place. As the coal gets finer, evaporation becomes relatively more important, and consequently, fine-coal screen driers are designed for longer coal retention as a rule. New designs include a step between the two screens to turn the coal over.

Top size vanes from as low as 1/8 with the fine coal units up to 2 or 2½ in, depending upon size of the unit, also the size of the coal, capacities of screen-type driers normally range from 25 to 125 tph of dried product.

3. Cascade, in which the coal flows down in steps.

Units employing the cascade principle usually are fitted with revolving shelves or trays in a round vertical shell. The coal is plowed or otherwise moved from one tray to the next in the drying process, which is largely based on convection. By tempering the incoming gases and by mixing them with the circulating air in certain types, the gas temperature at the point of contact with the coal can be cut to as low as 150 F.

Depending upon type and design objectives, driers of this type handle coal with a top size ranging from ¼ or ⅜ in up to 2 in, with some more suited to handling certain size fractions, such as, 2x⅜.

In another unit employing the cascade feature, coal is carried up on conveyor pans, or louvres, cascading down repeatedly while it works its way from one size ranges from ¼ or ⅜ up to 1 in.

4. Conveyor or carrier, in which the coal is moved through a hot-gas chamber on a perforated carrying strand or a wire-mesh belt. One type provides two stages of drying with both up- and downdraft gas flows.

5. Suspension, also known as "flash," in which the coal is introduced into an upward-flowing gas stream. These driers are widely used on coal ⅛ or ⅜x0—sometimes down to 10M or less. One recycles part of the stack gas to the furnace to keep down oxygen content and maintain an inert atmosphere in the drier. In a second type, part of the dried product can be recirculated if

feed moisture is naturally high or as a result of a high percentage of fines. A special trap is available for the latter unit for friable coals. Both also include provision for burning the dust from the cyclones or secondary separators.

6. Fluidized-bed, in which the coal is dried in a reactor in a fluid state. Though originally developed for a top size of ½ in, the units now are employed on sizes up to 1¼ or 1½ in. In the first installation, with a feed of 85 tph, $\frac{5}{16}$x0, 11% surface moisture, the final product averaged 2% surface moisture with a fuel consumption of 1 ton (*Coal Age*, July, 1956, p 76).

DUST SUPPRESSION—Dust is a problem with practically all heat driers, and particularly with those handling the smaller fines. Cyclones are the first line of defense and may be supplemented by bag-type collectors, wet collectors and water-spray systems (see section under "Air Cleaning"). High temperatures and high moistures in the spent gas have militated against the use of bag collectors in some instances and resulted in adoption of wet or wet-and dry (tumbler-type) collectors.

DRYER SAFETY — Ten recommendations by the USBM for promoting safety in the operation of heat dryers (R.I. 5198) are:

1. Good housekeeping should be stressed to prevent spread of combustible dust and eliminate ignition sources. Adequate vents should be provided, not only on cyclones but on other equipment and in the main structure of the plant.

2. Automatic controls — preferably with alarms—should be provided to shut down equipment if the temperature rises excessively, coal feed is interrupted or gas flow is interrupted.

3. Moisture content of the coal fed to the dryer should be maintained at a uniform level.

4. Temperature charts should be carefully watched and dryer operators should not tamper with equipment or controls.

5. Controls, valves and other sensitive parts should be inspected frequently.

6. Equipment should not be operated beyond rated capacity and definite upper limits should be placed on permissible inlet and outlet temperatures and the rate of coal feed.

7. Scrubbers and collectors should be placed beyond the cyclones to prevent excessive discharge of dust.

8. Adequate fire-protection and fire-fighting equipment should be maintained in the drying plant.

9. Long Ducts, and especially horizontal ones, should be avoided to minimize ignition hazards and reduce surfaces on which fine coal can accumulate.

10. All dryers, conveyors and other dust-producing equipment and transporting machinery should be made as dusttight as possible and operated to prevent dust leakage.

Crushing

PURPOSE: Conversion of unwanted or slow-moving natural coarse sizes into smaller sizes desired by the market, as distinguished from crushing for process purposes.

Although crushing or breaking for market purposes can take place in the preliminary processing, as in reducing the top size in the mine-run feed to a certain dimension, the majority involves specific sizes after hand picking or other cleaning and the goal usually is the production of stoker or other smaller sizes. An exception is anthracite, where practically all of the breaking is done in one or more stages before the coal goes into the cleaning units.

In bituminous plants, a favorite place for cleaned-coal crushing equipment is between the top and bottom strands of the mixing conveyor. This permits a wide flexibility in the sizes that may be run to the crusher, and also provides a convenient means of getting the crushed product back to the loading point, especially when the product is loaded without further sizing or other treatment.

Crushing may be—and frequently is—a part of a breaking and rescreening cycle for the production of double-screened stoker or other sizes, such as pea (see "Rescreening").

FINES LIMITATION—A major goal in clean-coal crushing operations—or, in preliminary breaking for the same purpose—is reduction to the proper size without excessive production of fines. Crusher design is one answer, and types and models now available permit good attainment of this objective. Operation is another answer and, among other things, involves stage crushing with rescreening between each stage. Some plants use as many as three or four crushers in series with vibrating screens between to unload the fines, which otherwise would result in increased grinding and pulverizing.

Rescreening

PURPOSE: Production of additional and sometimes special sizes not normally provided by the regular sizing equipment.

The growth of the domestic stoker was in large part responsible for the growth of rescreening in the bituminous field. With a longer size list, anthracite, in contrast, had no need to change its practice, beyond doing additional crushing, to satisfy stoker customers. Making bituminous stoker normally involved at least dedusting or the removal of fines under, say, ¼ in.

The vibrating screen, normally receiving its feed from the main sizing shaker, is the most-used type of rescreening unit in the bituminous fields. Air also has been used for dedusting at, say, 48M, in making the smaller stoker sizes. Rescreens also are quite commonly hooked up to receive material from cleaned-coal crushers when the natural output of the mine is not sufficient to meet stoker and other specialty demands.

Mixing and Blending

PURPOSES:

1. In blending, to achieve a high degree of uniformity of ash, sulphur and other constituents in the finished product. Blending is done mostly where metallurgical coal is involved and is accomplished largely at the raw-coal end. However, some metallurgical plants also blend the cleaned product a second time before loading.

2. In mixing, to provide sizes better tailored to the needs of the consumer.

Most of the mixing is done in the old reliable mixing conveyor. Unless crushing is introduced into the circuit, the mix is a natural one—in other words, the sizes in the mix are present in the percentages that naturally come from the final sizing screen.

"Prescription" mixing is a relatively new method of achieving a size consist in line with the customer's desires. A major advantage is that the consists can be absolutely accurate and also absolutely uniform.

Prescription mixing normally is limited to the smaller sizes designed for industrial or domestic-stoker use. It involves placing the various sizes in separate bins. The sizes may be as they naturally come from the sizing units, or they may be produced in part or entirely by crushing and rescreening. Mixing normally is achieved by feeding the sizes onto a gathering belt ending in a boom section. The rate at which the sizes are fed out of the various bins establishes the percentages in the mix. This rate may be adjusted by adjusting gate openings, but is considered less accurate than special feeders equipped with variable-speed drives.

Dustproofing

PURPOSE: Preventing the emission of objectionable volumes of airborne dust at the point of consumption by making dust and breakage resulting from handling and storing stick to the larger pieces.

The principal materials used for dustproofing coal are oil, calcium chloride and special chemical compounds, usually containing calcium chloride with other substances added. Calcium chloride and other materials pick up water from the air and thus provide a moist surface to which the dust adheres. Corrosion-inhibitors may be added to the chemical-type dustproofing agents to prevent possible attack of metal firing equipment and coal-handling parts.

Spray oils for dustproofing are available in a wide range of characteristics to fit the job being done. Equipment for applying them includes both beating equipment for spraying hot, and high-pressure atomizing, or "cold-oil" equipment for spraying cold. With the hot-oil systems, the oil-carrying lines may be paralleled by heating lines carrying steam or hot oil to keep the oil at the proper temperature at the point of application.

QUANTITY AND TYPE—Quantity of material necessary to achieve a desired degree of dustproofing depends upon both the size and type of coal being treated. Since the treatment is a surface job, and the surface to be treated increases as the size of the coal decreases, more material must be applied to the finer sizes. Porosity and other mechanical characteristics of the coal also influence both quantity and type of dustproofing material. With some very porous coals for example, good treatment with an economical quantity of petroleum-base material requires going to a very-high viscosity to prevent absorption of the material into the interior of the coal. Most of the high-volatile coals, however, may be treated satisfactorily with oils having a viscosity of around 200 deg.

APPLICATION — For maximum effectiveness with a minimum quantity of material, dustrpoofing material should be applied while the coal is in the air. Use of properly designed hoods prevents waste and insures maximum treating efficiency. Normally, such hoods are placed at the ends of loading booms or chutes, but they may also be placed over conveyors and other equipment, particularly those handling the larger sizes. The proper design of nozzle and the proper temperature at the point of application are key factors in the use of hot oil, and nozzle design is likewise important with other types of material to insure good treatment with minimum material quantities.

Regulation of material flow to the flow of coal may be accomplished by such steps as paddle-controlled valves at the ends of booms and chutes. The position of the valve is controlled by the thickness of the coal stream and in turn increases or decreases the flow of dustproofing material, preventing both overtreatment and undertreatment.

Freezeproofing

PURPOSE: Elimination of the labor trouble and adverse consumer reaction involved in the freezing of moist or wet coal in severe weather.

Where heat drying is not the practice and mechanical drying does not provide sufficient moisture reduction to prevent freezing, the coal may be treated with chemicals or oil. Such treatment usually is required with slack, screenings and other small sizes. The need for treatment is affected not only by the climate encountered but by industry custom and customer preference.

Salt and calcium chloride, usually applied dry, are the two main chemicals used for freezeproofing. The quantity depends upon the expected temperature and the moistness of the coal. For calcium chloride, the Calcium Chloride Institute offers the following guide:

	Lb CaCl per Ton at Specified Temperatures, Deg. F		
Moisture	+32 to +15	+15 to 0	0 to −15
3%	3.0—4.5	4.5—6.0	6.0—7.5
6%	6.0—9.0	9.0—12.0	12.0—15.0
9%	9.0—13.5	13.5—18.0	18.0—22.5

Chemicals may be thrown into the car by hand or may be dispensed by mechanical feeders into the coal stream as it is loaded. The latter normally provides more uniform and more accurate treatment.

Oil is finding increasing application as a freezeproofing agent. One operation, as an example (*Coal Age*, February, 1956, p 75), uses an 80-sec oil at the following rates: ¼x0 centrifugal carbon, 6 qt per ton; 4x2 or 2x1¼ crushed to 1¼ or ¼ in 2 qt; 1⅞x28M mix, 3.4 qt at a cost of 0.084c per ton. In loading coal under 1¼ in in size, the inside of every hopper is sprayed with 6 gal of oil for a 50-tonner and 7.6 gal for a 70-tonner at a cost of about 1c per ton.

Loading

PURPOSE: Economical placing of final product into car, truck or barge with a minimum of degradation and the lowest cost.

Anthracite is loaded into railroad cars almost entirely from storage pockets, reducing the number of loading tracks to one or two for many plants. Early bituminous practice was to provide a track for at least each major size, though a growing number of bituminous plants are providing pockets for certain sizes—usually stoker or other sizes in the smaller range. Loading of two cars on the same track is thereby possible by conveying one size to a pocket above or below the regular loading point.

Where only one size is produced, or where storage bins are provided for one or more additional sizes, loading of an entire shift's run of railroad equipment can be done with the elevated shuttle belt without moving a single car once they are set in by the railroad (*Coal Age*, March, 1953, p 94; October, 1957, p 76).

LOW-LEVEL DESIGN — Simplified design with a minimum of steel was the goal in the design of one recent plant (*Coal Age*, September, 1957, p 74) set alongside the loading tracks rather than over them. Two conveyors take the two sizes loaded at any one time up to two 2-way loading chutes, one for each of the two loading tracks. By combining through gates three sizes may be loaded on either of the two tracks, namely, 4x0, 1½x0 or ½x0.

Booms have long been used to lower the coal into railroad cars with a minimum of breakage at bituminous plants, and there is a tendency to extend their use to the smaller sizes, particularly stoker, though the chute still is the popular loading device for slack, screenings and other smaller sizes. Belt, apron and scraper-type booms are employed, with shaker booms as an added starter. The first two lend themselves to hand picking on horizontal sections. The third can be equipped with degradation screens, the breakage being returned to the mixing conveyor or other point by the bottom strand.

CAR HANDLING — Mechanical retarders provide positive control of car movement in loading, and there is a growing trend toward the use of motorized equipment, including special hoists which permit pulling a car back uphill if desired, or moving it back and forth several times to load the coal in layers.

Hoist-type retarders, incidentally, save overshooting and runaways, and consequently eliminate delays ranging from several minutes up to, where a column or columns may be knocked out, several days.

Automatic dropping and loading of cars is now coming into the picture. At one of the first installations (*Coal Age*, June, 1958, p 94) the system involves hoists with double ropes and sensing

switches to control car movement, transfer of coal flow from one to another, and uniform loading without the attention of an operator.

Clean-Coal Storage

Stockpiling clean coal is a growing practice at bituminous mines, as well as anthracite. The favored place is on the ground, though some silos and bins are employed. Capacity ranges up to several thousand tons. With large stockpiles, belt equipment is used in almost all instances for both stocking and reclaiming, with the reclaiming unit usually placed in a subway under the stockpile.

Piles may be single conical, laid down by a fixed-discharge conveyor; curved, laid down by a pivoting stacker conveyor; double conical, laid down by separate piling booms fed through a flygate, or by a reversible stacking belt; or long and narrow, laid down by a belt with traveling tripper. Lowering spirals or ladders are employed to reduce breakage where piling booms are not employed.

Truck Loading

It is possible to load trucks over the tracks or by chutes brought out from the plant but this, among other things, makes it impossible to service trucks except when the plant is running. Consequently, the usual practice is to provide bins or pockets for sizes sold to truckers. Spiral lowering chutes prevent breakage in filling bins holding the coarse sizes, and degradation in handling through the bins is removed by fixed screens in chutes, or by small shakers or vibrators.

Late truck-loading plants include, in the bituminous field, a multiple-silo installation in which the coal is distributed to the pockets by a pivoted elevated belt, which is swung on a curved track from one pocket to the other for filling purposes. Trucks are loaded through chutes.

In the anthracite field, a six-bunker plant is designed so that all operations are conducted by two men and accurate dispensing of orders is controlled by presetting dials to control flight feeders delivering at rates up to 5 tpm (*Coal Age*, January, 1954, pp 68-69).

Barge Loading

Barge-loading plants fall into about five classes, as follows:

1. **A simple dock** from which trucks dump into the barge at times when water conditions permit.

2. **The stationary chute type**, which is simple and low priced and works well where river fluctuations are not too great and banks are steep.

3. **Elevating-boom type,** with barges moved back and forth in the river beneath. The elevating boom allows more loading time if river elevation changes greatly. This type is advantageous where the bank of the river is considerable distance from the channel and the elevating boom and conveyor belt can be combined for travel across the flood plain.

4. **Floating-barge type,** with the loading boom mounted on a floating, or spar, barge and pivoted for easier loading. Requires a steep bank or fill to permit retraction and extension of the main conveyor with changes in water level.

5. **The tripper-conveyor type,** in which the barges are stationary and the loading chute moves back and forth to load and trim. Nothing has to be done to the barges but load them.

For examples of most of these types see (*Coal Age*, December, 1956, p 58; also October, 1956, p 60; June, 1957, p 74; January 1958, p 76.

TRAMP-IRON REMOVAL—Removal of tramp iron is handled at a number of plants, even though all sizes are washed, by suspended magnets or magnetic pulleys at the point the raw coal enters the plant. If washing or removal in the raw-coal stage is not practiced, iron removal should be done in the loading stage, especially with coal designed for stoker use. Facilities include magnets designed for use in the bottoms of loading chutes, as well as other types of units.

DEGRADATION REMOVAL – See "Clean Coal Sizing."

Water Handling

PURPOSE: Economical handling to keep cost down and meet stream-pollution regulations.

Questions involved in water handling at plants cleaning by wet methods include:

1. **Fresh-water supply** and treatment.
2. **Clarification** and recirculation.
3. **Final disposal** where circuits are or cannot be closed.

Makeup water requirements vary with the type of circuit. In a fully closed circuit, where sprinkling at the face results in an average of 5% surface moisture on the raw coal, which is the same as the average for the shipped coal, it can be seen that fresh water cannot be added. Normally, the only clear-water applications would be on pump glands and certain other essential applications. In an average plant, under these conditions, makeup water might well be only 50 to 75 gpm. In an open circuit, it might well be several times that minimum.

Sources of makeup water are:

1. **Deep wells.**

2. **Surface water** from lakes, ponds and streams, or from reservoirs made by dams to catch surface runoff.

3. **Mine water,** if available.

TREATMENT – Water from deep wells normally can be used without treatment. Mine water, on the other hand, may be quite acid, though there are exceptions. Surface water may or may not be acid, and may at times be contaminated by mud. Some authorities hold that the pH value of the water in the plant circuit should be between 8.0 and 8.5.

Other operators, however, feel that slight acidity is not objectionable. However, if the water is very acid, treatment with lime or soda ash is in order. Treatment permits plain steel for example, to be used instead of alloys, resulting in substantial savings in cost of equipment and materials, in replacement labor and in shutdown time. Even if the makeup is only mildly acid or neutral, acid may build up in the recirculated water and need treatment for that reason alone. Automatic equipment is now available for treating water efficiently and at minimum cost.

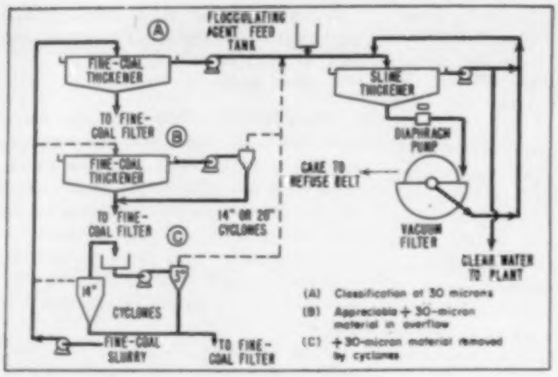
Unless there is an assured minimum flow adequate for plant need at all times, storage should be provided to tide the plant over periods of reduced flow.

Handling Wash Water

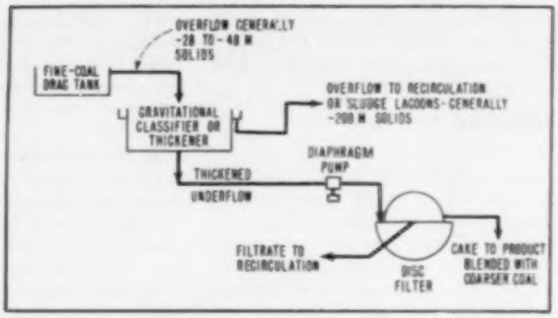
Stream-pollution regulations and the need, in many instances, for decreasing the loss of good coal to the refuse have resulted in major activity in the processing of wash water. A third reason for processing is to prevent the buildup of solids in water recirculated to washing units, since excessive buildup may materially affect the gravity of separation and consequently cleaning results. Available data indicate that many preparation men regard a solids content of more than 15 to 20% as excessive, while some try to keep it under as low as 5%.

Closed circuits frequently are mentioned as objectives in water handling —and are practicable in some instances though not in all. Reasons for circuit closing include: (1) elimination of discharge to streams, (2) reducing makeup water to that required for pump glands and other essential uses, (3) recovery of coal and (4) recovery of medium. As a corollary of closing, however, it is necessary to remove at least part of the solids, especially if clay and mud are present, to prevent solids buildup and a change in the gravity of the cleaning bath.

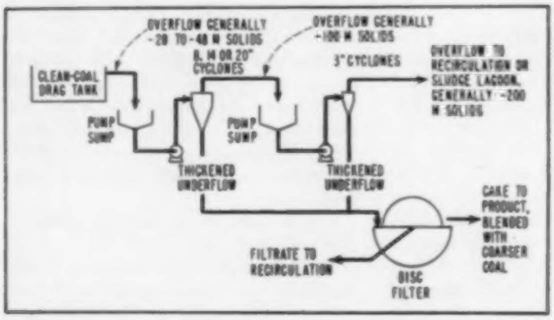
THE WHY OF BLEEDING—Closing a circuit may either be impossible or not desirable, however. If, as previously indicated, moisture on the coal leaving the plant is equal to that entering the



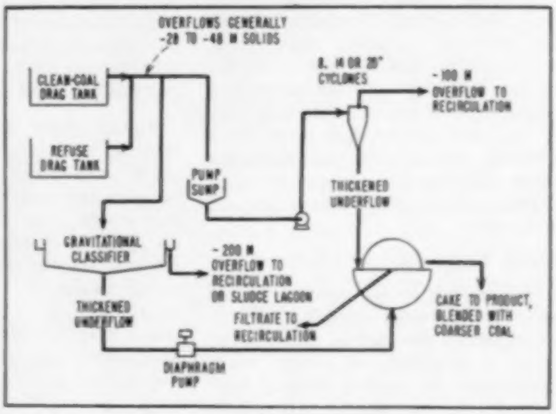
SOLIDS REMOVAL from wash water by flocculation and filtration, with variations to meet varying conditions.



VACUUM FILTRATION with gravity classifiers or thickeners for preliminary classification of the feed to the unit.



VACUUM FILTRATION with cyclones for preliminary classification of feed.



VACUUM FILTRATION with gravity thickeners and cyclones for preliminary classification of the feed before filtration.

plant, the quantity of makeup water that can be added without bleeding is nil. Thus, even gland-water requirements, if included in the water circuit, can force bleed under some circumstances. Some circuits, however, have been closed successfully. An example is summarized in the discussion of desliming in the "Washing" section of this Preparation Guidebook.

Practice and field custom also may result in bleeding of some to considerable quantities of wash water. It may, as an example, contain large quantities of high-impurity fines that would be difficult to clean. And under some conditions, it may be necessary to feed excess fresh water into the system for essential services, even if it is not required to rinse off clean coal and improve appearance as it might be in some instances.

Also, complete closing in the sense of allowing no escape of either coal or water may become impossible if certain steps are considered desirable in the preparation process—for example, desliming at 325M. The slimes must go somewhere and it is not always practicable to prepare them so they can be put in with the clean coal or the refuse.

Since bleed therefore becomes necessary in the majority of instances, the sludge pond also becomes necessary. Examples of its use include:

1. **Effluent containing minus 100M** flowed to 7-acre pond for solids settlement and subsequent reclamation by dredge and flotation; clear water returned for plant use because natural supply is not always sufficient.

2. **Settling pond** used to clarify waste water for water reclamation and to conform to antipollution regulations; recirculating water clarified in 125-ft thickener.

3. **Preliminary clarification** with settling tanks and large and small cyclones done primarily for coal recovery; some 98% of the minus 200M material bled off to pond to keep solids content of the system constant.

4. **Vibrating screens followed by settling pond** prevents clay buildup and enables plant to comply with antipollution regulations.

5. **Settling ponds used to keep solids content of circulating water** under 15% at plant using thickener, cyclones and vacuum filters. This is achieved by bleeding system when solids buildup requires it. Average solids content of bleed water is 17 to 20%.

SOLIDS REDUCTION—The goal in this operation, in contrast to fairly complete removal to meet pollution regulations, for example, is keeping the solids content of recirculated water to a reasonable figure; not over, say, 15 to 20%. The old-reliable conical or drag-conveyor settling tanks are standard equipment units for this purpose.

Examples of how sludge ponds may be used for this purpose are summarized in the preceding section. Other systems and equipment include the following example (see also examples in the "Dewatering" section):

Settling tanks to accomplish primary recovery of coal, with overflow to two batteries of large and small cyclones. Small cyclone overflow returned to system but part containing 98% minus 200M is bled off to keep solids content of system down to 10%. Underflow from both cyclones goes to disk filter for solids recovery prior to heat drying.

FLOCCULATION—Where natural settlement is depended upon for removing solids from wash water, results reflect the size of the material, the time provided for settlement, and the degree to which disturbance can be reduced. Flocculation of the material promotes settle-

ment, and some types of thickeners are built to permit flocculation along the settlement.

SOLIDS REMOVAL – Complete removal of solids may be desirable for two reasons: (1) salvage of good coal from the wash water, or (2) conformity with pollution regulations. Where coal is concerned, the same installation ordinarily accomplishes both results. Where refuse is involved, the only goal is meeting stream-pollution regulations.

Settling ponds, where space is available, are perhaps the simplest method of attaining sufficient solids removal to conform to pollution regulations. In some instances, they may be the cheapest, though not always. Their construction involves some expense, and if the capacity is limited they must be cleaned out from time to time. With ponds also, any fines that reach them, if of good quality, are either lost or can be recovered only at some added expense. Consequently, there is a trend toward extracting at least part if not all of the solids from the water before running it to the pond.

Equipment for accomplishing some solids removal before discharge to the pond may be merely the old reliable conical or drag-conveyor settling tank. Other units are thickeners, hydraulic or nonhydraulic classifiers, cyclones, and filters of various types. Combinations also are employed to meet specific conditions.

FILTER CIRCUITS–Three variations in a solids-removal flowsheet involving flocculation and complete closing of the circuit (*Coal Age*, January, 1955, p 76) are shown in an accompanying illustration. The goals are economical operation and removal of the solids so that they can be handled the same as any other solids, whether coal or refuse. Variation A is recommended where the fine-coal circuit includes a gravity classifier effectively classifying at 30 microns; Variation B, where gravity classification is such that an appreciable quantity of plus 30-micron material is found in the overflow; and Variation C, where the equivalent of two-stage cyclone concentration is employed.

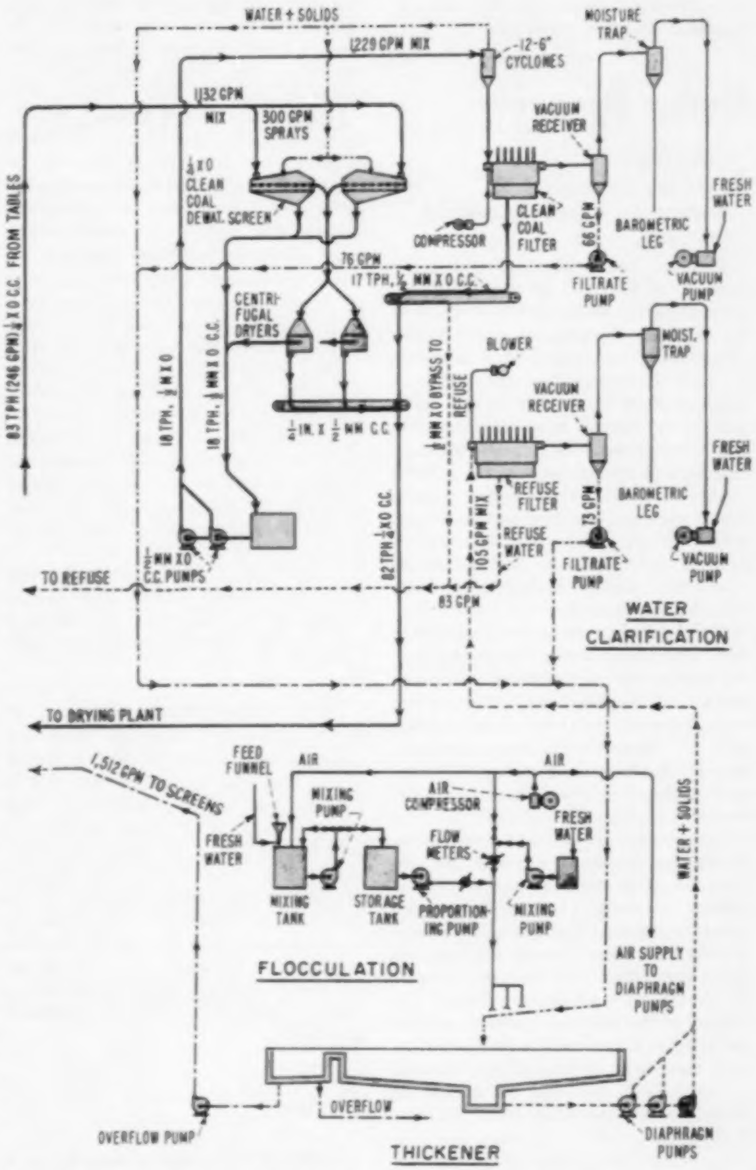
Three water-handling systems based on filters for final recovery of the solids also are shown in the accompanying illustrations. They are suggested for use where clay slimes are not excessive and closed-circuit operation can be obtained by filtration, or where the large slime fraction is bled off to a sludge pond. The three systems involve:

1. **Cyclone classifiers in conjunction with gravity classifier or thickener** delivering thickened underflow for filtration.
2. **Cyclone classifiers in conjunction with filters.** The two-stage system shown may be employed (1) where solids under 100M are too high in ash to be included in clean coal and (2) all underflows from both stages are filtered as clean coal. A buildup of minus 100M in the circulating water is prevented in both instances.
3. **Thickeners and cyclones** for preliminary concentration. Better filter operation is one of the advantages.

How filters are used in a circuit also including dewatering screens, thickener with flocculation, and cyclones is shown in another illustration. The system functions on ¼x0 and the final products are clean coal, refuse and clear water to the raw-coal shakers or to overflow. Thermal drying completes the job (*Coal Age*, October, 1957, p 76).

WATER CIRCULATION – Head tanks with automatically controlled pumps provide a uniform head on washing equipment, with consequent increase in the efficiency of separation, particularly with jigs.

Handling of casual and spillage water is simplified by proper design of the basement floor, which should be equipped with drains leading either to the pond or to a recirculating-water



WATER-CLARIFICATION CIRCUIT at one new property involves a combination of cyclones, thickeners, centrifuges and vacuum filters.

sump. Cleaning up by washing down is facilitated by such construction.

Sludge Recovery

PURPOSES:

1. **Water clarification.**
2. **Recovery of saleable material.**

Normally water clarification and the recovery of fine coal go hand in hand, although if clarification only is the goal the material may only be routed to the refuse bank, particularly if it is refuse in fact. However, the percentage of material finer than, say, 10 or 28M, may be substantial at many plants and may warrant recovery for its own sake, especially if it can be shipped without further processing. Even where processing is required, the quantity and character of the fines may warrant a substantial investment, particularly if clarification also is required or is desirable for any reason.

The equipment for recovering sludge from wash water, as noted in the preceding section, includes: settling cones and tanks, and thickeners and filters, along with hydraulic and nonhydraulic classifiers and cyclones. Cleaning equipment includes flotation units and special fine-coal washers, followed by normal dewatering and drying.

The preceding envisions recovery of the sludge as it is produced in the plant. Another form is recovery from old silt or sludge ponds or banks. Recovery equipment includes conventional shovels and also floating dredges. At some installations, the final step consists of drying. A modification, where the nature of the material warrants, is centrifuging to throw out the fine impurities and then heat drying. Where cleaning is considered desirable, a number of large plants have been built for froth flotation.

Refuse Disposal

PURPOSE: Final disposition of the refuse at a minimum cost and so that it will not result in a nuisance to neighbors.

The dump truck has taken over a large part of the refuse-disposal job in the coal industry today. Its advocates cite low cost and maximum flexibility, especially where it does not have to surmount too-heavy grades. The aerial tramway lends itself not only to disposal in what might be called normal territory but also to taking refuse across hills into neighboring valleys and the like. The side-dumping or revolving larry, in addition to ordinary situations, also is used to build out from hilltops or hillsides from bins fed by belt conveyors, tramways and the like.

Pumping of refuse is growing, though the question of taking care of the water to prevent stream pollution comes in. In some instances, it has been possible to pump into old mines or worked-out sections. The pumps will handle rather large pieces but normally pumping requires crushing to a top size of 2 or 3 in. Usually top size is held to not over ¾ or 1 in by prescreening or crushing, keeping down line velocity and cost.

Even where pumping is not involved, it may be economical to crush, particularly where large rock is involved. Jaw or gyratory crushers may be indicated under such circumstances. Benefits of crushing include easier handling, a more-compact pile and greater ease in maintaining a running surface where trucks are used.

Where refuse output is large, and especially where trucks and similar equipment are employed, a bulldozer for spreading and compacting may pay off.

FIRE PREVENTION—Prevention of firing of refuse dumps has been the subject of considerable research in recent years, and the spread of automotive haulage has made possible new and effective methods of piling, compacting and sealing refuse to practically eliminate firing. One method of layering, compacting and sealing against air is described in *Coal Age*, June, 1951, p 91. Development of the method also was accompanied by steps to extinguish an old fire by stepping, trenching and filling and covering with earth as conditions dictated.

Power

PURPOSE: Adequate capacity and voltage with a minimum of maintenance.

VOLTAGE — Accepted voltage for most of the stationary motors in preparation plants is 440, leaving in most instances only the question of whether 2,300 V should be used for certain large units, such as pumps, crushers and the like. A rough rule is that motors of 100 hp and larger should be 2,300.

TRANSFORMER LOCATION—Packaged substations with oil-filled transformers are available for outdoor service, with nonflammable units for indoor. Outside is the place for the transformer station if the highline voltage is over 10,000 and the reduction to 440 is made in one step. If the supply voltage is less than 10,000, the packaged indoor substation with nonflammable transformers is the general choice, principally because it can be placed closer to the center of the load.

CONTROLS—Starters grouped in factory-assembled control cabinets are now standard for preparation plants. One central cabinet is satisfactory for a small plant, but a large plant may require cabinets at several locations to keep the motors reasonably close to the starters. Draw-type starters which can be pulled out for quick replacement are coming more and more into favor.

Dust is one of the major problems in location and operation of starting equipment. The best solution seems to be one or as few control rooms as possible made fairly airtight and fitted with blowers to maintain a slight positive pressure inside the rooms. Air forced into the rooms should be filtered.

CAPACITORS—The induction-motor load of the preparation plant produces a low power factor, which adds to the bill and heats conductors and motors. Capacitors should be installed in the plant to bring the lagging power factor up to unity. Theoretically, an appropriate capacitor should be placed at each motor. However, practical limitations of cost, space and maintenance generally make it advisable to group the capacitors in the control room.

Maintenance

PURPOSE: Efficient plant operation with no or a minimum of interruptions. A collateral goal is conduct of maintenance with a minimum cost for labor and materials.

Maintenance is necessary because of wear and corrosion inevitable in operation, and the effects of the elements, for example:

1. **Rusting** of the exterior and interior, including structural members and equipment, as a result of rain, snow and water.
2. **Corrosion** from acid water and, on occasion, from the gases given off by burning refuse dumps.
3. **The effects of heat and gases** involved in heat drying.
4. **Wear** from the handling of coal and rock.
5. **Lack of lubrication,** overloading and other abuse, faulty electrical service and the like.

Maintenance Factors

All wear and corrosion, cannot, of course, be eliminated. Use of the proper

materials and proper designs when a plant is built, or when parts or sections are added or replaced in existing plants, are major factors in maintenance cost. These materials and designs include the following:

1. **Location of heavy equipment,** particularly of the rotating or reciprocating type, on or as near ground level as possible: cuts structural cost and reduces the effects of weight, motion and vibration.

2. **Bracing, steel weight, balancing and damping** to provide stiffness, reduce or eliminate unbalanced forces, and prevent the transmission of motion and vibration to the structure.

3. **Use of protected steel** and special roofing and siding materials, including asbestos-cement, aluminum and stainless steel.

4. **Protective coatings and paints** for steel exposed to rain, moisture, gases and the like.

5. **Neutralization of acid water** with lime or soda ash. Automatic feeding equipment now available facilitates this job. Frequently, neutralization will make it possible to get much-longer life from ordinary steel, saving both in material cost and replacement labor.

6. **Use of corrosion- and abrasion-resisting materials** for screens, chutes, flumes, water lines, pumps and so on, including plastic, rubber and asbestos-cement water lines and connections, and rubber-pinch and orifice-type valves. Stainless steel for bolts, for example, can solve some annoying corrosion problems in certain preparation applications.

7. **Use of linings to resist wear** and, with some types, corrosion. Examples include glass, tile and brick in chutes; and rubber, plastic, sand-cement and ceramic linings for tanks and cones. Another form of lining is special hard metal for conveyor bottoms. Hard-surfacing of wear points or the use of special wearing strips are natural steps.

8. **Use of totally enclosed, splash-proof and other special motors** for dusty, wet and similar locations, plus moisture- and dustproof controls or the location of controls in rooms with blowers using filtered air and maintaining a slight positive pressure inside the rooms at all times.

9. **Good lubrication** with proper equipment and quality lubricants of the correct types applied at the correct intervals. Centralized automatic systems are growing in favor.

10. **Regular inspection and cleaning** of preparation equipment. Cleanliness and good housekeeping for the plant as a whole naturally supplement these, and to facilitate housekeeping a growing number of plants are being equipped with hoods and covers for certain equipment connected to exhausting and dust-collecting equipment, plus vacuum systems for cleanup.

Quality Control

PURPOSES:

1. Attainment of the desired preparation standards with a minimum of deviations and a maximum of efficiency.

2. Securing data on the quality of shipments for possible use in adjusting complaints and as a final check on preparation performance.

Checking and control measures are both visual and mechanical or chemical. With lump, for example, the bulk and weight of a proper sample, and the increased difficulty of getting a representative sample, make mechanical and chemical tests difficult, and reliance must be placed largely on visual inspection. In washing, visual inspection—by operators who know their business—of the feed and draw material can reveal changes in condition immediately and permit adjustments to be made promptly, although this type of checking is subject to the normal human frailties.

Even with mechanical and chemical methods, the change in conditions takes place before the results are available, thus re-emphasizing the importance of adjusting operating conditions to provide the desired results as nearly automatically as possible. However, even though the data are obtained after the fact, mechanical and chemical tests are necessary to provide positive evidence of whether or not the desired results are being attained and permit adjustment if not.

SAMPLING—Where the tonnage is at all large and a careful check on quality is essential, one or more specialists should be charged with the responsibility of collecting samples. Depending upon the control setup, they also may run sink-and-float tests and prepare samples for more-elaborate chemical tests.

Number of samples and sampling intervals depend upon control and quality data required. Egg and lump—and perhaps nut and pea—may be sampled at longer intervals and perhaps only once a shift or longer. The problem grows more critical with the smaller sizes, especially where sales are made on a specification basis. As a result, many plants sample stoker and screenings, as examples, at intervals of as small as 15 min, while every hour is fairly common.

Automatic samplers installed at transfer points, expecially for the smaller sizes, reduce the labor involved in sampling and tend to increase the accuracy. Manual methods include the car sample taken at a number of spots, but the trend today is toward cutting samples out of the coal as it flows into the car. A convenient method is to mount a narrow box of the requisite length and depth on a pivoted arm which is swung through the coal stream.

If the sample is intended for chemical analysis in the laboratory, time and labor can be saved by placing the preliminary sample-preparation equipment—crusher, splitter and the like—at or near the point the sample or samples are taken. As an example, some plants have provided platforms alongside the loading booms for sample preparation.

TEST PROCEDURE—Samples for checking cleaner operation normally are processed by sink-and-float. The equipment may be on the cleaning floor or at some other convenient location in the plant. The weight of the sink in a standard sample of cleaned coal is a working indication of how the cleaner is performing. The results also may be converted into fairly accurate ash figures by reference to a curve based on the average results of analysis of a representative number of samples.

Checking the efficiency of washer operation also requires testing of refuse.

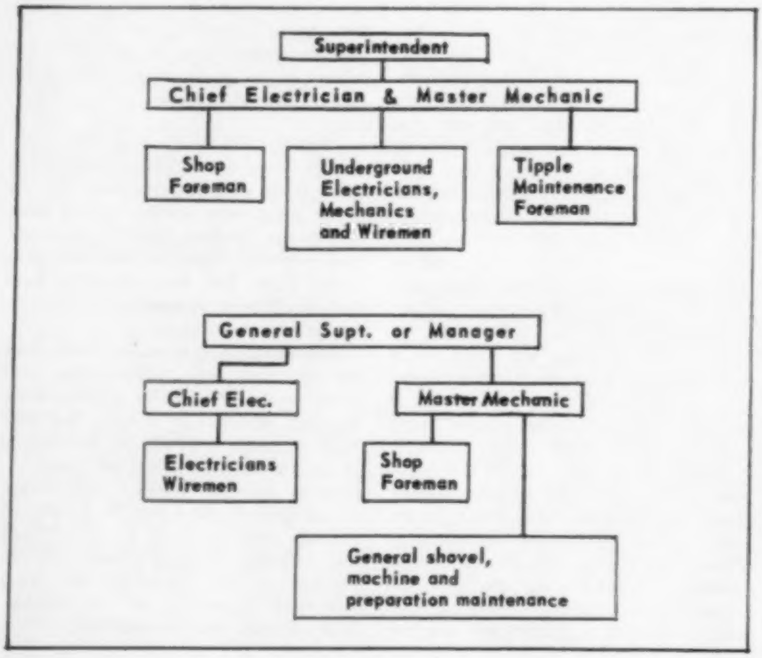
More precise results of course can normally be expected by laboratory procedure, although the time interval necessarily is longer. Equally or more important, the laboratory is the only means of attaining all the chemical and physical data on both processing results and the character of the shipped coal, including ash, sulphur, moisture, heat content, fusion and softening temperatures of ash, and so on. Also, the presence of laboratory facilities permits research into suggested changes in preparation procedures and forecasting of results. Therefore, more and more plants are being supplemented by well-equipped laboratories. An example is the subject of an article in the April, 1950, issue of *Coal Age*, p 90.

SIZING CONTROL—Since the accuracy of screening can have a major effect not only on realization but also on customer acceptance, quality control must take in size checking also. Facilities will vary with the circumstances at the individual plants but they should at least include a test-screen unit.

RECORDS—The type of records kept for operating and quality-control purposes should provide for putting down the data obtained in a form that will make it easily available to and usable by operators, supervisors and other interested persons. Graphic presentation by curves may be a part of the record system, and the data to be entered may include such things as valve settings on washers. For shipments, the record may show car number, size, ash, sulphur, heat content, moisture and so on.

Rather than emphasizing what any (3) trucks, tractors, graders, etc. However, the basic principle is assignment

The Maintenance Guidebook



THE NECESSITY of having an effective maintenance program has become more and more apparent as machines continue to assume more of the production load, as greater production capacity becomes concentrated in individual units, and as wages and cost of materials increase. Maintenance is no longer an auxiliary division in a coal organization but rather an essential part of the mining setup. No company, for the most part, can operate today at a fair profit without an effective maintenance program.

The four major objectives in organizing a maintenance system are:

1. **Preventive maintenance** is the key as cost depends upon keeping machines running at full capacity as much of the time as possible.

2. **Unit changeout**, which in effect is a variation of preventive maintenance, requires that various components of a machine be changed out systematically before trouble develops.

3. **Machine improvement** is an essential part of maintenance and involves conducting studies on all equipment to find weak points so that they can be improved.

4. **Immediate repair of equipment** after breakdown is essential. Nothing being perfect, break-downs and production interruptions cannot be completely eliminated. Therefore, the maintenance system must provide for such breakdowns.

Organization and Manning

Encourage operating and maintenance personnel to work as a team.

Delegate authority along with responsibility to eliminate "buckpassing."

Assign sufficient specialists to make inspections and repairs but don't overman.

Take advantage of idle shifts to perform major inspections and repairs.

Keep the overhaul-schedule of equipment on cycle—don't let it lag.

SHARED RESPONSIBILITY between operating and maintenance departments facilitates efficient maintenance.

Rather than emphasizing what any particular department should do, the goal in maintenance is the program—what it should be and what it should do. Once the program is fixed, the responsibilities of the operating and maintenance departments become clear. Under this approach, the responsibility for an effective maintenance program is one for the operating management, which also exercises the final authority. For example, experience at one operation indicated that on the working section the face boss should be in control of all maintenance men and functions on the section. Divided responsibility resulted in confusion, buckpassing and failure to keep on top of the job.

But while final authority logically rests with the operating department, the cost, capacity and complexity of the new machines now handling coal production require additional skills and manpower to keep them running at rated capacity. Consequently, the responsibility for sustained production which only the maintenance department can discharge is increased. In other words, as a practical matter, production depends to a major extent on maintenance, and the maintenance department must be organized and staffed accordingly.

For an indication of how this works out at the face, the foreman has the responsibility for seeing that his unit is operated with a minimum of delays – in other words, that it produces at the maximum rate.

Work Sequence

With a well-organized and sufficiently staffed maintenance force, prompt and effective maintenance can be accomplished. The logical approach would be to consider the necessary type of work to be performed. This leads to the "three-echelon" system, which breaks down as follows:

FIRST ECHELON—Inspection and minor running repairs at the face or in the pit make up first-echelon work. Normally, inspection is conducted by the section or pit electrician and mechanic, along with the operators, and the same men handle running repairs and adjustments.

First-echelon work also includes servicing the equipment, such as, lubrication, checking and inflation of tires (trucks at strip pits and rubber-tired equipment underground), cable maintenance and repair, and other similar operations.

Typical setups for manning face maintenance are one mechanic or electrician for one or two units, underground, and one or more men for each major class of equipment in the larger strips—for example, (1) shovels and draglines, (2) drills, pumps and compressors, and (3) trucks, tractors, graders, etc. However, organization is subject to considerable variation, and at smaller operations, or at operations with certain types of equipment of a rather simple and rugged nature, running maintenance may be handled by one man or one man and a helper.

Whatever the type of operation, however, the basic principle is assignment of sufficient specialists to a unit or a group of units to keep break-downs to a reasonable minimum, since overmanning, in maintenance as in other activities, runs up the cost in excess of the benefits in additional lost-time reduction. Economical maintenance requires proper manpower.

Practice Trends

"PREVENTIVE" maintenance being emphasized as a result of increased use of more complicated and costlier equipment, and to obtain lower production cost.

MAINTENANCE BUDGETS increasing accordingly and will assume an even larger share of coal cost.

MORE MONEY will be spent on training than ever before as a result of a shortage of qualified maintenance personnel.

Operating Reports

Inspection Guide for Deep-Mine Equipment—Complete guide on what to look for and how to go about inspecting deep mine equipment. *Coal Age*, October, 1957, p 84; November, 1957, p 64; December, 1957, p 66.

Dual-Purpose Motor Tester—Unit capable of testing repaired or rebuilt motors under actual load conditions. *Coal Age*, October, 1957, p 92.

Testing Device Handles Three Maintenance Jobs—Unit presets 12BU Joy loader gathering head liquid clutches, load tests 9J motors and tests head and traction speed reducers. *Coal Age*, October, 1957, p 108.

Stainless Steel Sheathing Covers Plant—Stainless steel cover for plant exterior reduces maintenance and is resistant to corrosion. *Coal Age*, October, 1957, p 108.

The Beltman's Guide—How to install, repair, inspect and maintain belts. *Coal Age*, March, 1958, p 122.

Maintenance Training for Supervisors—How training starts, what is taught and what the gains are. *Coal Age*, September, 1955, p 68.

Improvement Through Training—Program for mechanics and electricians involves 3-hr classes twice a week for a minimum of 48 hr of instruction and practical excercises in electrical theory and trouble-shooting. *Coal Age*, April, 1957, p 76.

Getting More from Portable Cables—How machine design and cable construction, plus proper application and care in use, contribute to reliability, service and minimum cost for electric cables. *Coal Age*, February, 1956, p 94.

Automatic Lubrication—How centralized systems are applied and how to save in lubricants, lubricating delays and in parts by accurate, automatic lubrication in accordance with use. *Coal Age*, August, 1955, p 60.

New Hydraulic Fluids—Equipment using hydraulic fluids, estimated annual consumption, possible synthetic fluids to reduce fire hazards. *Coal Age*, January, 1957, p 82.

SECOND ECHELON—Major inspec-

FOREMANS TROUBLE REPORT FORM FOR MECHANICS

--- To be filled in by Foreman ---

SECTION NUMBERS: ____________ SHIFT: ____________ DATE: ________ FOREMAN: ____________

TIME TROUBLE NOTED: ________ AM ________ PM
TIME CALLED MECHANIC: ________ AM ________ PM
TIME MECHANIC REPORTED TO SECTION: ________ AM ________ PM
TIME MECHANIC COMPLETED JOB: ________ AM ________ PM
TIME MECHANIC LEFT SECTION: ________ AM ________ PM

FOREMANS DIAGNOSIS OF TROUBLE: EQUIPMENT DESCRIPTION: Type: ________ Ser No.: ________

--- To be filled in by Mechanic ---

MECHANICS SIGNATURE: ____________

ACTUAL WORK PERFORMED BY MECHANIC:

WAS JOB COMPLETED TO STANDARD? ____ IF NO, STATE REASON WHY AND EXPLAIN WHAT'S REQUIRED:

IMMEDIATELY AFTER MECHANIC HAS COMPLETED JOB HE WILL TURN THIS WORK ORDER OVER TO THE FOREMAN THAT MADE REQUEST. THEN MECHANIC WILL REPORT TO HIS REGULARLY ASSIGNED DUTIES.

NOTE: TO FOREMAN: If above job was not completed to standard the oncoming mechanic must be notified by the above reporting foreman.
This work order to be forwarded to the maintenance superintendent.

CONFIRMING WORK SHEET

SHIFT: ________
DATE: ________ SER. NO: ________
MINE: ________ UNIT NO: ________ DEPT. NO: ________ MODEL: ________
EQUIPMENT DESCRIPTION: ____________ TYPE: ________

Description of work done this shift

NOTE: Attach copy of order for supplies to this report

TIME REQUIRED TO DO JOB: From Time: ________ M to Time: ________ M Date: ________

List of Materials used this shift

Quantity	Part No:	Part Description:	New	Old	Price	Total

Equipment Description: ____________ Serial Number: ____________
Mine: ____________ Section: ____________ For Month of: ____________ 19__

M = MECHANICAL DELAY E = ELECTRICAL DELAY C = CABLE SPLICE

Record of Delays							Production			Cost
Date	Delay Explanation:	From Time	To Time	Total Delay in Minutes M	Total Delay in Minutes E	Total Delay in Minutes C	Tons Loaded	Tons Hauled	Places Cut	Daily Supply Cost

FOUNDATION OF ANY MAINTENANCE SYSTEM is good reports and records.

when the feeders run. Such equipment recommend when certain equipment Where several machines make up a

SECOND ECHELON—Major inspections involving some opening of cases and enclosures, and also major repairs or replacement jobs done during idle periods make up second-echelon maintenance. Part of this work, such as, inspection and replacement of certain units and assemblies, may be done at regular intervals, and part will be done when necessary to avoid a potential breakdown or take care of an actual one.

Such work normally falls to special groups, which may be: (1) permanent task forces or "bull gangs," (2) special groups of men normally employed in the underground or field shop—or perhaps the main shop, or (3) temporary groups made up by assembling the regular section or pit men on off-shifts or idle days. Similar task forces normally handle the maintenance of preparation plants.

THIRD ECHELON—Normally, third-echelon work involves complete overhaul of a machine on the basis of time, tonnage, yardage or hours worked. Underground units and small stripping units, as examples, normally are brought to the shop, or sent to an outside custom shop, for complete dismantling and rebuilding, and large stripping units are moved back from the face or out of the pit to prepared overhaul areas.

Aside from equipment, third-echelon work takes in such other activities as the repair of conveyor belts, large truck tires and similar items, for which some companies have special shops or shop sections. Others use custom shops or manufacturers' repair and service facilities.

Since overhaul, in addition to skill in dismantling and assembly, requires, as a rule, basic skills in metal-working and the like, and normally also requires bringing the equipment to the main shop or a prepared overhaul area, maintenance men handling this class of work are largely kept on it alone, though certain men occasionally may be sent into the mine or pit to handle certain face or field jobs. The number of men and the specialties involved again depend upon the situation at the particular operation.

Mine No ______

Repairman's Weekly Inspection Report

Loader No. ______ Date ______ Location ______

MOTOR

Brushes and Commutator ______
Holders, Springs and Leads ______
Armature Bearings, Grease ______

CONTROLLER

Fingers and Tension ______
Segments and Cylinder ______
Wiring ______

CIRCUIT BREAKER

Contacts ______
Tripping ______

HYDRAULIC SYSTEM

Control Valve ______
Four Way Valve ______
Pressure Pump ______
Hoses and Connections ______

Fwd. and Reverse Leathers ______
Front Jack Leathers ______
Rear Jack Leathers ______
Swing Cycl. Leathers ______

CLUTCHES

Front Clutch ______ Slipping Amperes ______
Rear Clutch ______ Slipping Amperes ______

CONVEYORS

Rear Chain Tension ______
Front Chain Tension ______
Compound Chain ______ Grease ______
Flights Rear Conveyor ______
Flights Front Conveyor ______

GATHERING HEAD

Seal Packing Rings ______
Grease ______ Dirt ______
Gathering Arms ______ Bolts ______ Bits ______

TRANSMISSION CASES

Grease ______ Leaks ______

CRAWLER DRIVE

Chain Tension ______ Grease ______

SWING ROPES

Ropes and Clamps ______ Sheaves ______
Remarks ______

Coal Drill Inspected ______
Cutting Machine Inspected ______
Repairman ______ Ck. No ______
Helper ______ Ck. No ______
Total Hours ______

INSPECTION REPORTS help by uncovering conditions which might result in breakdown if not attended to in time.

Reports and Records

Make certain that reports and records provide necessary information on the causes of delays and time lost.

Concentrate maintenance where the greatest gains can be made by using information received from detailed reports.

Have equipment inspected in detail at regular intervals.

Keep cost records of repair parts and labor for each unit.

Route summaries of reports and records weekly or monthly to responsible operating or maintenance heads.

Maintenance progress cannot be made effectively without proper reports and records. Even though paper work is involved, careful study of the types and numbers of forms will reduce it to a minimum—and will make that minimum more valuable.

Types of Reports and Records

DAILY DELAY OR OPERATING REPORT—In breakdown prevention—the No. 1 goal in maintenance — the daily delay or operating report is a must. It shows what the mechanical and electrical failures were and how much time was lost with each. Also, these reports may be expanded to show other delays and their causes to permit appropriate action. Thus, they become running time studies of machine performance, and provide invaluable data for eliminating the causes of reduced efficiency.

The daily report may be rather simple, per the accompanying example, which concentrates on production and delays only. Or, as in the second example illustrated, it may include details on labor, parts used and a description of work done. In this particular example, both mechanic and foreman fill in part of the report of each delay.

Periodic maintenance reports and daily lubrication charts, as illustrated in the accompanying examples, furnish check blocks as various parts are lubricated and also list duties and responsibilities of greasers. Another example shows periodic maintenance reports including parts to be inspected and on what type of equipment.

Automatic records of operating and delay time are possible on certain types of equipment. Examples are swing recorders for shovels and draglines, and electric clocks hooked up with feeders in preparation plants so that they run only

down frequency and time increases. However, there is a drawback. Investment in equipment—and in parts and

location, and provides space for recording information on the units of each machine that are included in the change-

training programs, either conducted on company premises by company-employed trainers, or by outside training

when the feeders run. Such equipment eliminates human errors in computing or entering lost time and, in the case of the feeder clock, permits checking on how the plant is doing at any time merely by a glance. Swing charts, on the other hand, permit detailed study of what has been happening if it should appear necessary.

WORK-NEEDED REPORT—To attain fully the goal of preventing breakdowns, some form of reporting on work or adjustments is a necessity. It permits reporting a part that seems likely to fail so that the necessary steps may be taken to repair or replace it on the next idle shift.

Work needed may be reported either on the front or back of the regular delay form, or it may be reported on a special form. Where it is entered on the regular form, special handling may be necessary to make sure that both the repair foreman and the superintendent, for example, get the data they need without delay. Or, the forms may be made out in duplicate or triplicate and routed accordingly.

Where separate forms are used, the original naturally goes to the repair foreman, with perhaps a copy to the superintendent. In some instances, the form includes space for reporting on when the work needed was done, with or without copy to the superintendent, as a further means of insuring that prompt action is taken.

INSPECTION REPORT—As a second means of preventing breakdowns, a number of mining operations have instituted inspection reports. An example is illustrated elsewhere in this section. The frequency of such reports can vary from daily to monthly or longer, with a week or a month as the most common. The reports are derived from special inspections of a varying degree of thoroughness, and normally involve going into certain cases and the like. In other words, the machine is given a more thorough examination than would normally be involved in a quick daily once-over. Inspections may be made by the regular section electricians or mechanics, or by special men from the mine or central shop. These men at the same time can make certain adjustments and repairs, and can note larger jobs that may require taking the unit out of service.

A recent newcomer to mine maintenance personnel is the electrical-mechanical inspector. His primary duties are to conduct and plan inspection schedules for all equipment, make out equipment reports and submit them to responsible operating and maintenance heads, to make sure that work orders are carried out and completed as scheduled, and to recommend when certain equipment should be taken out of service for overhaul.

UNIT COST RECORD—There is a growing trend toward keeping a complete record of repair parts and labor unit by unit. Labor in this instance normally means special labor beyond the usual attention given by the section mechanic—in other words, shop and special labor required for major repairs and overhauls. Paper work is increased but the accurate unit record provides, among others, these advantages:

1. Excessive expenditures may signal waste or loss of parts sent into the section for running repairs, as well as lack of lubrication, abuse of the machine by operators, and so on.

2. Rising expenditures may signal the need for overhaul earlier than normally scheduled to prevent excessive machine breakdowns.

3. Consistently higher expenditures for one type of machine, compared to another of equal capacity, may make it desirable to standardize on the lower-maintenance unit, other things being equal.

4. Data on the value of special materials—for example, stainless steel—can be readily obtained to show if they are worthwhile or not.

For maximum convenience, unit cost records may be kept on cards designed for rotary or other quick-viewing files. The data for the records naturally comes from requisitions for parts and materials submitted by the foremen or other responsible officials, and from reports on parts used and labor expended by the repair foreman. Naturally, also, summaries of the unit records should be made at regular intervals—perhaps monthly—for the superintendent and other officials having jurisdiction.

RECORD DISTRIBUTION—As implied in the preceding paragraphs, reports and records can be fully effective only when they, or the data from them, are regularly routed to the responsible operating or maintenance heads.

Who Should File Reports

The type of report will, in many instances, indicate who should file it—for example, a report on work completed by the repair foreman, or on lubrication by the head of the lubricating crew, if one is employed. Daily delay and operating reports may be filed by the foreman or the operator of the key machine, with some arguing for the machine operator since the foreman may not be with the machine at all times. Operator reports, if that is the system, naturally should be filed through the foreman, who will check and countersign.

Where several machines make up a unit, there may be a question as to whether reports should be required of the several operators—for example, cutters, shuttle-car drivers, etc. Among other things, such reports might be valuable by focusing operator attention on the need for good maintenance and care in operation. Practically, however, one report, especially if prepared by or with the cooperation of the foreman, usually can provide the necessary information.

Reports on work needed likewise may be filed by the operator, the foreman or the section mechanic, working with each other.

Whatever the number and scope of the various reports, the rule should be a practical system.

Spare Equipment

Provide spare equipment, when practical, to reduce the effects of breakdowns.

Furnish extra equipment to replace units scheduled for overhaul.

Standardize mining equipment as much as possible to reduce maintenance work and cut inventory.

One method of alleviating the effects of major breakdowns is keeping spare units on hand, provided the cost of such spare units can be kept within reasonable limits. It is manifestly impracticable, for example, to buy two 30-yd shovels, one to substitute for the other when it breaks down. The goal here must necessarily be one of making sure that breakdowns are kept to the absolute minimum, and that the shovel be maintained in such condition that major overhauls are required only at rather long intervals.

With smaller units, such as underground loading machines, a much-greater opportunity exists for keeping spares on hand without excessive investment. General practice is to provide a spare for each 3 to 5 major production units, such as, loaders, cutters, continuous miners, shuttle cars, etc.

Basically, the number of spares depends upon conditions and particularly on the extent to which preventive maintenance reduces major breakdowns. Time necessarily is involved in getting the inoperative machine out of the way and the new one in, regardless of how close the spare may be. If breakdown time can be kept below that figure without exception, there theoretically would be no need for spare units, except to maintain output during overhaul periods.

But since breakdowns have an annoying habit of causing lengthy delays, there is an opportunity for the spare units, and that opportunity increases as break-

down frequency and time increases. However, there is a drawback. Investment in equipment—and in parts and labor to take care of breakdowns—also increases. The conclusion is that preventive maintenance on the working units is the real goal, and will reduce the need for spare equipment and also the breakdown cost.

A second factor determining spare-unit practice is the overhaul schedule. With intervals of 6 mo to 2 yr on major underground units and on certain surface units, and with overhauls requiring up to a month or more, spares are a necessity if production is to be maintained at a certain level. Usual practice is to take an underground machine out of the section, or a small portable unit out of the strip pit, and send in the spare unit. Certain underground mines, however, follow the practice of keeping extra completely equipped sections, and transferring the crews for the overhaul period, on the basis that moving men is less costly than moving equipment.

Standardization

Standardization of mining equipment, of course, has its limits, and complete standardization would make it difficult to work in new types of machines and thus take advantage of their characteristics. But with fewer types of equipment, including components such as motors and the like, there is a much greater opportunity for learning all about the equipment and how to handle it. Also, repair-part inventories are reduced and the problem of receiving, storing and issuing parts is simplified.

Unit Changeout

The most recent advance in mine maintenance is the unit changeout system. Although this system involves a rather large initial outlay of capital the results after the program gets under way show a substantial decrease in machine downtime and replacement of parts.

The success of this program depends on five major factors:

1. **Organizing the program.**
2. **Evaluating the equipment** to determine within safe limits the average life of the various units that are to be changed out periodically.
3. **Supplying an adequate number of spare units** and replacement parts.
4. **Allocating a sufficient number of men** to carry out the program, both in the shop for rebuilding the units and inside the mine for changing them out.
5. **Keeping an accurate record** of each equipment item.

Once the program is in operation, accurate records must be kept to insure its success. Records, for the most part, consist of a master equipment chart. This chart lists all equipment and its location, and provides space for recording information on the units of each machine that are included in the changeout program. The information includes frequency of changeout, when they were changed last and when they are to be changed out again.

Personnel Training

Schedule training for operating managers, supervisors and operators, as well as maintenance men.

Proper training not only increases the knowledge of electrical, mechanical and hydraulic principles, it also makes better electricians and mechanics with an increased interest in their work. Another by-product of conducting training courses is developing unrealized leadership talent among maintenance men.

OPERATING MANAGERS AND SUPERVISORS—While they need not, perhaps, be required to take formal courses, particularly in the details of maintenance, operating managers and supervisors should know what good maintenance means and how to go about getting it—and also keeping it.

An example of a program conducted by the company itself is detailed in the September, 1955, issue of *Coal Age*, p 68. The emphasis is on the electrical side of maintenance; and training facilities include actual trouble-shooting methods on motors and controllers, as well as special wiring diagrams for use in the classroom and underground. The training is done by the electrical engineer, and includes examinations to ascertain progress in learning.

OPERATORS — Here, again, formal courses may be impractical, but since a careless or uninformed operator can raise delay time and maintenance costs significantly, he also should be made aware of what good operating practices mean in both high production and low cost, and of what he can do to prevent machine delays and breakdowns. The logical men to provide him with the necessary information and skill are the foreman and the section or field mechanic or electricians.

MAINTENANCE MEN—At least two types of skills are necessary in achieving maximum results in maintenance, repair and overhaul. One type is the basic skill, such as, machining or welding. Three ways of obtaining men with such skills are: (1) hiring men already proficient, (2) hiring graduates of training courses, and (3) setting up company training programs, either conducted on company premises by company-employed trainers, or by outside training establishments to which the employees are sent.

A second skill is proficiency in diagnosing and taking care of trouble on specific equipment units, where a good knowledge of what the unit is and how it operates is imperative. If this skill is not already available, or if it is felt that it could be upgraded, sources of training include:

1. Factory instruction, either at the manufacturing plant itself or through service representatives visiting the mine.
2. Extension courses made available by colleges and universities.
3. Trade-school courses.

Even if only a basic knowledge of electrical and hydraulic principles was gained, the extra insight should result in a better electrician or mechanic, especially if it resulted in his taking more of an interest in his work because it was more meaningful.

Rated Voltage

Keep substations within maximum transmission distances to working sections.

Limit the amount of trailing cable on machinery.

Check voltage regularly with recording-type instruments.

Provide protection for trailing cables.

Furnish necessary supplies to repair cables and keep a spare cable handy.

It is difficult to overemphasize the importance of rated voltage at the motor terminals as a factor in maintenance—and in unit production. DC motors, for example, tend to slow down almost in proportion to voltage drop, and slow-acting machines, plus frequent cable and armature failures, tend to result in don't-care operators.

When trailing cables or motor conductors are subjected to high current overloads—one result of reduced voltage—the resistance of the copper conductors increase, the cable drop rises, the voltage to the machine is further reduced, the machine automatically calls for more current with added heating, and the vicious circle continues—possibly to the point of cable or motor failure. Under extreme conditions, copper can be heated to 600 F or higher, at which point it will burn even if nothing else fails before.

As an example of what can happen,

consider a 50-hp motor, 0.85 efficiency, served by a 1/0 cable 300 ft long and trying to do the same work at 270 and 180 V. The extra current loss in the conductors at 180 V could approximate 0.4 kw. On this basis, the extra heat generated in 1 hr is equivalent to between 6 and 7 lb of coal. It is almost the equivalent of operating a household stoker inside a jacket of cable or motor insulation.

Maintaining Voltage

Admittedly, the preceding is an extreme case, although not unknown in actual operation, where heat has been known to cause trailing cables to almost explode into flame. It points up, however, the need for maintaining rated voltage at machine terminals, especially in view of the higher horsepowers being crowded into motors used on face machines, and into others as well.

The causes of low voltage include:

1. Substations too far from the working face (see article on electric power beginning on page 88 of this issue for recommendations on maximum distances).
2. Excessive cable length.
3. Inadequate feeder and return capacity.
4. Cables too small.

In addition, excessive heating results from the following:

1. Layering on reels or in piles decreasing cable rating because of inadequate air circulation.
2. Inadequate or no overload protection. Properly rated fuses or properly set circuit breakers should be used.

Regular voltage checks therefore become a necessity in preventive or production maintenance, and may even warrant the use of recording-type instruments at strategic locations. Otherwise, the section electrician may well be charged with the responsibility for making regular checks. And to make these checks effective, a program of moving up substations and beefing up feeders and returns as necessary must be followed. This might well be the responsibility of the chief electrician, maintenance supervisor or electrical engineer.

Since even under the best of conditions heat is generated when current flows in conductors, and the higher horsepowers now being employed in the same or only slightly larger space aggravate the problem, the best in motor and cable insulation should be employed, such as, asbestos-fiber compounds, silicone and the like. Blowing motors is a well-established method of keeping them cool in certain types of service, and cooling by water jackets is coming into the picture for certain motors subjected to the most-severe duty, as on continuous miners.

Cable Maintenance

Even with rated voltage, delivery of the necessary power to the operating machines usually involves a trailing cable of some type. Aside from low voltage and overload, the major causes of cable failure, particularly underground, are:

1. EXCESSIVE TENSION – Install spring-type shock absorbers, keep proper tension on reel, adjust reel to prevent back spooling.

2. MECHANICAL DAMAGE–Avoid running over cables, replace broken sheaves and guides, avoid pinching cable.

Additional data on failures and their causes appears in a comprehensive discussion of cable types and cable maintenance in the December, 1953, issue of *Coal Age*, p 75.

In the event a cable fails in spite of all precautions, reducing the time lost requires quick restoration of the service. Some ways of doing this are:

1. Use of compression connectors and special hand or power tools for quick connection of the power and ground wires to save time. Special portable welding equipment also is used to make splices electrically in the section (*Coal Age*, January, 1951, p 70). A fairly common failure is trying to keep a cable with too many splices or otherwise in less than top-grade condition in service. The cost of the delays in some instances will repay the cost of a new one in as little as 2 to 4 days.

2. Use of spare cables to permit quick replacement of the entire cable. An alternative with at least certain types of equipment is the use of sectionalized cables, which not only are easy to install but also lend themselves to the quick replacement of a new section for one that has failed.

Temporary splices should be kept to a minimum. One rule allows six, after which the cable is removed and sent to the shop for rebuilding by permanent welded or compression-connected splices and vulcanizing. Some mines remove the cable with a lesser number of splices. At certain operations where attendants are required at substations or other facilities, these men are provided with the necessary repair and vulcanizing facilities and take care of splicing, vulcanizing and other cable maintenance, thus saving the wages of a specialist.

FAULT-FINDING–Failures in long high-voltage cables, such as on strip shovels, can result in a long search for the trouble point, with attendant loss in production time. Electrical fault-finders now on the market cut this time loss to a minimum by giving a quick and accurate indication of where the failure occurred. Or, the mine can make its own (*Coal Age*, May, 1953, p 108).

Lubrication

Establish a lubricating schedule and standardize on the number of lubricants used.

Provide necessary equipment for applying lubricants properly.

Keep seals and fittings in good condition.

Have reports and records kept on all lubrication.

Responsibility

Attainment of efficient lubrication requires acceptance of perhaps three responsibilities.

1. Selection of lubricants and lubrication equipment. This responsibility normally falls on the maintenance department, though the importance of lubrication might well warrant the employment of a lubrication engineer—at least where a company operates several mines and a large number of producing units. Sources of help in lubricant selection include lubricant suppliers and the engineers of the machine builders. The services of these experts should be used.

2. Establishment of a lubricating schedule. Scheduling, with attendant reports and records, is perhaps one of the most-vital elements in efficient lubrication, and here again the responsibility rests on the maintenance department or the lubrication engineer.

Lubricant Application

The third responsibility in lubrication is getting the job done, which responsibility may be placed on the maintenance department alone or may be shared by the maintenance department and the machine operators and/or section or pit mechanics and electricians. The lubricating system varies with the type of machine and when and where it is used. The three general systems are:

1. Hand Lubrication. This usually involves grease guns or spout-type or other oilers for fluid lubricants. Where this is the practice, lubrication normally is handled by either the machine operator or the mechanic or electrician assigned to the machine or section, or by a special oiler, as with large stripping units. Lubrication can be combined with inspection and running maintenance, as with belt conveyors underground, for example.

Hand lubrication involves more transfers and containers, as a rule, and makes for more complicated distribution in ad-

DAILY LUBRICATION

MINE: ____________ SECTION NO. ________ DATE: ______________________

LOADER SERIAL NO: ________ , ________.

Lubrication Points:	Lubricated Yes	Lubricated No	Use Lubricant
1. Frictions RH & LH	☐	☐	Hydl. Oil
2. Gathering Head Gear Case RH & LH	☐	☐	Y
3. Cat Drive Speed Reducer RH & LH	☐	☐	Y
4. Crank Pin Bearing	☐	☐	Z
5. Gear Case Seal	☐	☐	Z
6. Idler Arm	☐	☐	Z
7. Cat Idler RH & LH	☐	☐	Z
8. Conv., Tail Roller	☐	☐	Z
9. Cat Drive Sprocket Bearing RH & LH	☐	☐	Z
10. Conveyor Hinge Pin Upper & Lower	☐	☐	Z
11. Rope Sheaves	☐	☐	Z
12. Conveyor Chain	☐	☐	Hydl. Oil
13. Cat Drive Chain	☐	☐	Hydl. Oil

DUTIES AND RESPONSIBILITIES OF GREASES

1. Properly lubricate all equipment assigned to him.
2. Help float out S/Car crewmen for lunch.
3. Each shift the greaser will clean out the S/Car reel cases and, keep the sheave wheels free of accumulation of obstructive material, also, clean the operators platform and any other accumulation of obstructive material as may be encountered on the wheels and chasis of the shuttle car.
4. Fill to capacity all hydraulic tanks on equipment assigned to him.
5. Grease daily all miscellaneous equipment that may be assigned to his section such as:

   Car Hoist — Conveyors, Head
   Elevators — and tail pieces.
   Piggybacks

6. After performing regular assigned duties, the greaser is at the disposal of the foreman in charge.

PERIODIC MAINTENANCE

	Date: Month	3	3			
	Date: Day	13	13			
Periodic Inspection	Operating Shifts:	1/2	3/4	5/6	7/8	9/10
Motors 20 Shifts	Loaders	6771				
	S/Buggies					
	T/Trucks					
	Machines					
	Piggybacks					
Clutches 40 Shifts	Loaders					6771
Clutches 40 Shifts	S/Buggies					
Cable Reel 40 Shifts	S/Buggies					
	T/Trucks					
Contractors & Switches As Scheduled	Loaders	6771				
	S/Buggies					
	T/Trucks					
	Machines					

Periodic Shuttle Car Lubrication

	Date: Month	3		
	Date: Day	13		
S/Car Serial No.	Operating Shifts:	1/2	3/4	5/6
3220	S/Cars Day			
	S/Cars Nite			
	Symbol			
	Date Greased			
3223	S/Cars Day			
	S/Cars Nite			
	Symbol			
	Date Greased			
	S/Cars Day			
	S/Cars Nite			
	Symbol			

INSPECTION REPORTS and lubrication charts insure repair and adjustments before breakdown.

dition to increasing the risk of contamination. In view of this, one company (*Coal Age*, May, 1956, p 68) maintains central storage tanks (in old mine cars) at central points in working sections. The tank is filled from a large oil car by the supply crew, and is pumped through a hose to a convenient point near the face units.

An improvement in small hand gun reloading is the use of manufacturer-filled grease cartridges, which reduces the reloading time and eliminates contamination.

2. Lubricating Trucks and Special Crews. Such trucks are used both underground and at strip pits. Hand lubrication may be desirable for several reasons, including low working height, cramped quarters, or the type of unit, such as, a belt conveyor. However, since individuals with other duties frequently are called upon for lubrication under this system, the chance of human error is greater. Hand lubrication also increases the chances of contamination, and may require stopping the units during the working periods, thus reducing output.

The preceding are among the reasons why a number of mines have placed responsibility for lubrication on special crews and have provided them with lubricating trucks. A typical underground truck usually is operated by a crew of two men, who visit all units in the mine or a section of the mine once a day on the off shift. The truck usually is equipped with tanks for two types of lubricants, with a third tank for hydraulic oil, and may be provided with hoses for blowing fittings, motors and the like as necessary with air from the compressor used in dispensing the lubricants. Where the truck is track-mounted and offtrack equipment is employed, the offtrack equipment may be brought to the loading station once a week, for example, for thorough inspection and lubrication, with lubrication by hand at other times. The truck crew also fills lubricant containers for hand lubrication.

As for results, one mine bought a truck to serve eight loaders and nine cutters, and in the first 18 mo of use had only three bearing failures. Lubricant consumption was reduced 65% in the same period. Another mine using a truck reports that a loader can be greased completely in 10 min.

Trucks for strip equipment also may include fuel-dispensing equipment. One such unit comprises a gas-powered compressor, lubricating pumps, for lubricating hoses on reels, and four fuel drums with the necessary hoses. Air pressure is used for dispensing fuel as well as lubricants, and the unit serves tractors, drills and other smaller mobile units.

3. Centralized Automatic Lubrication. Minimum manpower and positive lubrication at all times are among the reasons for the rise in use of centralized automatic lubricating systems in coal mining. These systems dispense either grease or oil—more usually grease—and among

SHOVEL NO. ______ **SMALL SHOVEL LUBRICATION RECORD** MONTH OF ______ 19

DAY OF MONTH	1	2	3	4	12	13	14	15
AFTER INSPECTION OF LUBRICATION WORK IS COMPLETED, SHOVEL OPERATOR AND PIT FOREMAN MUST SIGN REPORT. IN ABSENCE OF PIT FOREMAN, LOADING FOREMAN SIGNS								
FOR LUBRICATION WORK COMPLETED USE CHECK (√) SIGN SHIFT	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm	12-8 8am-4pm
HOURS OR MINUTES DEADHEADING								
HOURS OPERATED LOADING COAL, ORE, ETC.								
PARTS LUBRICATED PIT NO.								
(1) Truck Frame and Propelling Machinery (Lower Works)								
All Fittings Below Deck Lubricated								
Circle Rollers Lubricated								
All Cat Assembly Fittings Lubricated								
Propel Bearings Lubricated								
Open Gears and Sliding Surfaces Lubricated								
Enclosed Gear Case Oil Level Checked								
(2) Revolving Frame and Machinery Units (Upper Works)								
All Fittings in House Lubricated								
All Open Gears Lubricated								
Enclosed Gear Case Oil Level Checked								
Hydraulic Oil Level Checked								
Gasoline or Diesel Engine Oil Changed								
Light Plant Oil Changed								
Electric Motors and Generator Bearings Lubricated								
Flexible Couplings Lubricated								
Air Compressor Oil Changed								
Air Filters Cleaned								
(3) Front End Equipment								
All Boom Fittings Lubricated								
Boom Support Cables Lubricated								
Hoist Cables Lubricated								
Open Gears and Sliding Surfaces Lubricated								
Enclosed Gear Case Oil Level Checked								
All Bucket Fittings Lubricated								

(1) TRUCK FRAME AND PROPELLING MACHINERY

PARTS TO BE LUBRICATED:
Drive Tumbler Shaft and Transverse Propel Shaft Bushings.
Longitudinal Propel Shaft and Propel Brake Shaft Bushings.
Center Pintle Thrust Washer Oil Pump (Note Instructions On Pump)
Center Pintle Bearing Bushing.
Take-Up and Idler Tumbler Bushings.
Steering Clutch Shifter Collars.
Steering Clutch Sliding Jaw Guide Bars.
Propelling Bevel Gear Cases.
Cat Side Frame Gear Cases
Swing Rack Teeth
Roller Track Bars.
Roller Pins.

(2) REVOLVING FRAME AND MACHINERY UNITS (Upper Works).

PARTS TO BE LUBRICATED:
Vertical Propel Shaft and Upper Propel Shaft Bushings.
Propel Bevel Gears and Sliding Propel Gears.
Hoist Pinion Sleeve Bushings.
Hoist Gear.
Drum Shaft Bearings
Intermediate Shaft Bearings
Intermediate Reduction Gear Case.
Vertical Swing Machinery Gear Case.
Vertical Swing Shaft Lower Bushing
Electric Motors and Generators
Hydraulic Pressure System
Operating Lever Shaft Bearings, Bell Cranks.

(3) FRONT END EQUIPMENT

PARTS TO BE LUBRICATED:
Boom Point Sheave Bushings.
Shipper Shaft Bushings.
Saddle Block Bushings
Dipper Handle and Saddle Block Slide Plates.
Shipper Shaft Gear Case.
Intermediate Gear Case.
Intermediate Shaft Bearings.
Dipper Padlock Sheave
Dipper Door Hinge Pins, Padlock Pins, Bail and Handle Pins
Wire Ropes

PART	HOW OFTEN TO LUBRICATE	TIME TO LUBRICATE
Point Sheaves Crowd Fittings	3 times per shift 3 times per shift	1. Start of shift 2. Two hours after starting 3. At lunch time
Fittings in House	2 times per shift	1. Start of shift 2. Middle of shift
Circle Rollers	1 time per shift	1. Start of shift
Cat Assemblys	Mud and Water Conditions 3 times per shift	1. Start of shift 2. Two hours after starting 3. After lunch time
	Dry Pit Conditions 2 times per shift	1. Start of shift 2. After lunch time
	Deadheading Every 1,000 feet	1. Start before deadheading
Open and Partially Enclosed Gears Sliding Surfaces	Normal Operating Conditions 2 times per shift on loading	1. Start of shift 2. Lunch time
	Deadheading As often as dry spots appear, or approximately every 1,000 feet	
Hoist Cables	Every 24 operating hours. Never let hoist drum cable grooves run dry.	When convenient When dry
Boom Support Cables	Once a month	While machine is idle
Enclosed Gear Cases	Check oil level once a shift	Start of shift
Hydraulic System	Check oil level once a shift	Start of shift
Air Compressor	Check oil level once a shift Clean air filters and change oil once a month	Before starting

Center Pintle thrust collar at lower end is lubricated by hand pump on truck frame at idler tumbler end. Operate pump plunger two or three times, twice a shift.

GASOLINE OR DIESEL OPERATED MACHINES: Clean air filters, change oil and filters each 300 operating hours. Always drain while oil is hot.

Always wipe off grease fittings to avoid forcing dirt into bearings.
Shovel operator, pit or loading foremen will be held responsible for checking lubrication work done during their shift, also the keeping of monthly lubrication record chart on shovel up to date.
Pit or loading foremen and operator are to sign record chart at end of their respective shift.
It shall be the duty of day shift pit foremen to see that there is enough lubricating materials and equipment on shovel to carry over the afternoon and midnight shifts at all times.

Inspections of mechanical and lubrication conditions of shovel will be made by maintenance supervision and lubrication engineer during all shifts.

Lube Engineer

GOOD LUBRICATION MEANS

- SAFETY
- LOWER OPERATING COSTS
- FEWER SHUT-DOWNS
- MORE PRODUCTION
- JOB SECURITY

LUBRICATION EFFICIENCY is promoted by definite scheduling and reporting, as with this form for small shovels.

other advantages reduce the chances for contamination to almost nothing, since the lubricants usually are dispensed from the original containers or if not, with a minimum number of transfers. Applications of centralized automatic systems include:

1. Loaders, cutters, continuous miners and shuttle cars underground. In some instances, the systems are designed to give the bearings a shot whenever the machine hydraulic system goes through a cycle, thus requiring no manual attention whatever. Some, however, prefer to leave part of the lubricating cycle to the operator because with automatic initiation there is the possibility of over-lubricating, with grease getting into, for example, motor windings.

2. All bearings in preparation plants, with the possible exception of motors.

Automatic systems, in fact, have included dispensing of grease to underwater bearings on sludge conveyors.

3. Heavy-duty off-highway trucks, including wheel and steering bearings. For a description of how it is done at one operation, with substantial savings in truck time, lubricants and replacement parts see *Coal Age*, August, 1955, p 60.

4. Large stripping shovels and draglines, and possibly other smaller units. One company divides between hand and automatic lubrication of stripping equipment on the basis of (a) cost of special lubricating equipment v. the type of machine and its expected life, and (b) the fact that in many instances the man still would be necessary. Other major factors in this company's program (*Coal Age*, January, 1952, p 76) include lubricant standardization, detailed scheduling of lubricant application, reports on lubricant application, and prevention of contamination.

Results reflect (1) a reduction in the cost of lubricating materials—from 3.05c per ton in 1944 to 2.20c in 1950, in spite of increases in material cost, (2) a reduction in maintenance expense, and (3) a reduction in the losses in production time. The program includes both pit and preparation equipment, and at that time the reduction in cost of maintaining stripping equipment was estimated at $75,000 a year, and of maintaining a dry preparation plant (centralized lubrication), $20,000 a year.

Seals and Fittings

Effective lubrication, in addition to all the other factors involved, depend upon (1) the lubricant getting into the bearing, and (2) the lubricant staying in the bearing. Therefore, fittings, oilers, grease cups and the like must be of the proper type and must be in condition to function as needed. Otherwise, no lubricant. A No. 1 job of any men handling lubrication therefore is to check to make sure the fittings and lubricators are in operating condition, and to report promptly if they are not in shape.

Bearing seals are unglamorous but nevertheless are vital to make sure that the lubricant is retained so that it is available for the job it is called upon to perform.

Scheduling

An efficient lubrication program depends upon definite scheduling of the work, accompanied by definite instruction as to the type of lubricant to be used. This means a written document for the information and guidance of all who have anything to do with lubrication, and this document may also serve as a report on work done. Tags enclosed in plastic envelopes may, for example, be tied to tractors, with one side of the tag showing points to be lubricated, type of lubricant to be used, and when lubrication is to be done, and the other side serving as a record of lubrication performed. Similarly, more comprehensive schedules may be posted in strip shovels and preparation plants, or supplied to foremen and mechanics underground. In any event, the goal is to have something definite and thus avoid hit-or-miss application, buckpassing and the like.

Reports and Records

Unless somebody checks, adhering to an efficient system in lubrication, as in all other activities around the mines, is practically impossible. This means reports and records which, even though they involve paper work, provide the basis for intelligent operation and control.

Reports may be rather simple in nature, merely recording that a certain machine was lubricated on a certain date. An important item in any report, however, is whether certain bearings refused to take lubrication or took too much, since this is a signal that trouble is probably in the making. A rise in quantity used on each machine or in each application is a further signal that machine condition is deteriorating, or that certain parts need attention. And if experience has shown that adequate lubrication can be secured with certain quantities of materials, figures on quantities used also will reveal waste and loss through contamination or otherwise.

Lubricant Selection

The recommendation of the equipment manufacturer is the starting point in lubricant selection, with the second major source of data the service departments of the oil companies. A third source of information, provided proper records are kept, are the lubricating and delay reports, which may indicate that a change in type is necessary. When all the preliminaries are completed, lubricants then should be bought on performance rather than on general representations, and the rule should be the highest possible quality in view of the penalties now suffered as a result of equipment breakdowns. The latter, for example, comes into consideration when gear oils, for example, are being specified. Use of the extreme-pressure type covers all applications with a quality product and eliminates the chance of misapplication in lubricating the operating units.

STANDARDIZATION — Too many types of oils or greases lead to confusion, misapplication, contamination and loss. Careful study of the lubricating problem will show, in many instances, that a lesser number of types of high quality will do the job, since the variety of lubricants available include many with the necessary spread in characteristics fitting them to several applications.

As an example of what standardization can accomplish, one large stripping organization, also operating a large and modern preparation plant, cut the number of lubricants from 29 to 9, as follows:

	Types Before	Types After
Motor oil, heavy-duty detergent	2	1
Gear oil, all enclosed gear cases	4	1
Antifriction-bearing grease		1
Plain-bearing grease	5	1
Open gears	3	2
Cable dressing	5	1
Compressor oil	3	1
Hydraulic oil	7	1
Totals	29	9

On-the-Job Supplies

Keep spare repair parts close to all working sections.

Provide adequate storage space for spare parts.

If a part is not close at hand, what might be only a minor breakdown can turn into a major stoppage if the item, such as a chain link or hydraulic hose, is missing, requiring a special trip to the supply house or the main shop. Limiting down time therefore requires keeping an adequate stock of the smaller, frequently used items in the section or pit, where they are readily available for the mechanic or electrician. Where heavier, less frequently used parts or critical assemblies are involved, one or more can be kept at a central location, perhaps on a truck or carrier, but still handier to the working sections or pit than in the main shop.

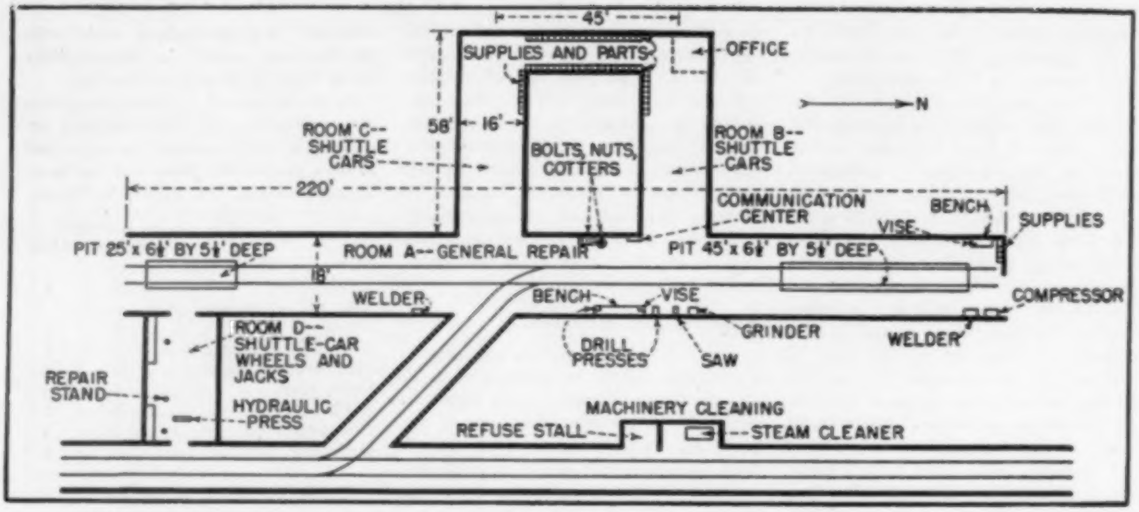
To prevent loss or damage, section parts should be kept in a supply cabinet, a parts box, or in lockers, drawers, etc., in the foreman's or repairman's shanty or office. Some mines also have found it advisable to keep certain special tools with the parts so that they are handy when needed. Lamps or other heating facilities should be provided for parts subject to damage by moisture.

Mobile Repair Units

Furnish means by which troubleshooters can get to breakdowns quickly.

The repairman's jeep, with space for carrying parts and supplies and lockers

types of mining—contour in particular,



MODERN MINE SHOP includes machinery-cleaning section and special rooms for certain equipment and parts.

or compartments for tools, has become a fixture at many underground mines because of the speed with which it can deliver both men and materials to the scene of a breakdown. Similar units also speed up the work of wiremen, bratticemen and other service workers. Other mobile maintenance units include welding trucks—gas and electric—where there is an opportunity to use such equipment in fresh air.

DEEP MINES—Skid-mounted "maintenance centers" (*Coal Age*, September, 1955, p 78) are among the newer types of mobile repair units. Designed particularly for trackless mining and moved by hitching it to a shuttle car, the centers consist of 4 x 5 x 12-ft steel tanks with flat tops providing bench surfaces for work. Among other advantages, a supply of spare parts is always within 100 ft of the face.

For bringing machines to fresh-air locations, and for other purposes, including moves, crawler-mounted pullers or carriers have been found very useful at a number of mines, especially in low coal. And where machines must be moved long distances, such as loaders, miners and shuttle cars to main shops, lowbed transporters speed up the operation and save wear and tear on the units.

Where pullers are not available, several tricks may be employed to move disabled machines—for example, a drill motor with an adapter to power the crawlers on a loader for short moves.

STRIP MINES—Mobile maintenance equipment at one strip operation includes the following, aside from greasing and fuel trucks:

Small-tool truck for all types of small hand tools and parts normally required on maintenance jobs.

Large-tool trailer for transporting heavy tools required in major jobs on big stripping units.

Flat trailers for moving wood blocks, cribbing and the like.

Special heavy-duty trailer for hauling buckets and shovels up to 100 tons.

Small-parts truck.

Truck-mounted crane with boom sufficiently long to handle all lifting jobs necessary in maintaining 40- to 50-yard shovels.

Welding trucks.

The number and variety of units reflects the fact that this is a very large operation. At a smaller strip plant, this number and variety would not be practical, but a welding truck plus a general repair truck, or one truck for both purposes, represents possibly the minimum of mobile units.

Communication

If for no other reason, a good communication system from the face or pit to the main office and repair shop normally will pay for itself through reduction in breakdown losses alone. In strip pits, two-way radio is one of the answers, and includes certain mobile units such as in the superintendent's car, the repair foreman's car or truck, and the cabs of the key stripping units. A good telephone or trolleyphone system yields the same results in deep mines.

Mine Shops

Locate shops at the most economical places for deep and strip mine.

Although a few deep mines make a practice of maintaining machines up to the stage of semi-overhaul in the working section, lack of space, the difficulty of doing welding, light and coal dust, among other things, normally dictate the transfer of major repairs, replacement of assemblies and semi-overhaul to shops maintained for that purpose. Some of these conditions do not prevail in strip pits, and consequently there is a greater opportunity for doing second-echelon work away from the shop. And with large stripping units, the only practical way to work on them is in the field in special repair areas, though some components and assemblies are processed in the shop or shops. In preparation, also, the nature of the plant and equipment also dictates doing a major part of the work on the job, though parts and assemblies may be removed for shop repair and return.

Shop Location

DEEP MINES—Distance and whether or not the equipment must be hoisted up slopes or shafts are among the factors involved in location of deep-mine shops. A third is facilities for quick moving of units from the face to the shop and back, such as, special transporters. Where good transportation facilities exist, and hoisting is not involved, it may be possible to locate mine shops on the surface and thereby get the advantage of space, natural light and the like, including convenience, at a somewhat smaller expenditure. But where the distance is great, and where hoisting is involved, there are strong reasons for locating the shops underground. With proper planning and design, they can be made almost as convenient as surface shops—and as efficient—and have the major advantage of being closer to the actual working sections.

Moving the shop as the mining location shifts also is possible with certain

types of mining—contour in particular, as well as auger. Some such operations use small prefabricated buildings mounted on skids or trucks as shops or supply houses or both, moving the unit or units as needed as the mine opening moves around the outcrop.

Certain types of maintenance work, such as cable repair, may be done in small specialty shops set up at substations or other points where attendants are necessary to take advantage of what otherwise would be idle time.

STRIP MINES—Central location and convenient access from highways, both on the property and off, are among the considerations involved in locating strip-mine shops. Frequently, these considerations result in the shop being located with the other mine facilities, such as, the mine office and the preparation plant, especially since big units are necessarily repaired in the field, and trucks, tractors and small units can be brought in under their own power or by the use of transporters, even when they are not required to come to the preparation plant regularly. An exception might be a truck garage and shop where the trucks haul to field stations or to rough cleaning plants moving coal to central plants by rail after rough cleaning.

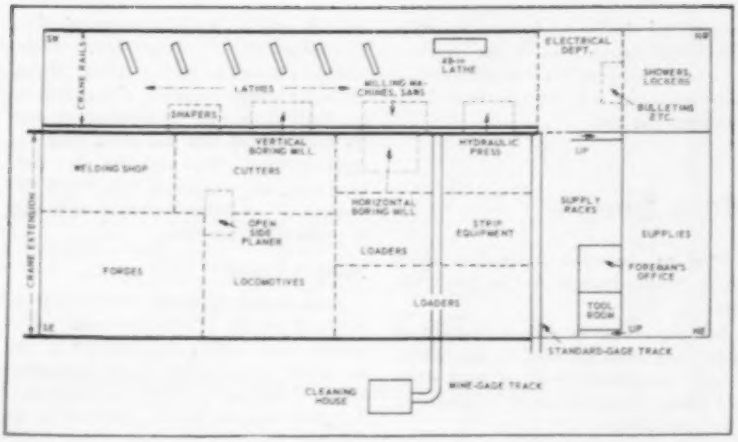
Specialty shops employed by some stripping organizations include a portable welding shop, fabricated from corrugated steel, and mounted on wheels, and large enough to go over a truck or other unit. This facilitates body and other repairs where the unit cannot readily be brought into the shop without dismantling.

Shop Facilities

Even the simplest deep-mine shop for major repairs, replacement of assemblies and the like should be equipped with a pit, hoisting facilities and a parts store room, plus the necessary special tools required for the work done. Parts-cleaning equipment should be installed if possible to speed up this operation and facilitate subsequent work.

At the other end of the scale, mine shops may be large and elaborate and able to handle everything up to complete dismantling and reassembly of all types of machines. One shop of this type, located near the bottom of the hoisting shaft, includes high-intensity lighting, a general repair section with two pits plus overhead cranes and small hoists, two bays for shuttle-car service with hoisting facilities, an office, cabinets for parts, a room for repair and servicing of shuttle-car wheels and hydraulic-jack units with monorail crane, and a cleaning recess with permissible-type steam cleaner supplemented by a refuse stall.

Tools include saw, floor-type drill press, vises, bench drills, floor grinders, hydraulic press, welding machines, and portable electric and air grinders. Facilities also include 32 tool cabinets built into the walls, and a compressor.



MAIN SHOP provides facilities for overhauling equipment including special machine work, steam cleaning, welding, forging and electrical work.

In-Plant Facilities

Though not a part of shops, certain permanent facilities of a shop type serve very useful purposes in certain maintenance applications. Examples are compressed air and welding gas lines and outlets in preparation plants, and arc welders in preparation plants and strip shovels. Time saving is the major advantage.

Overhaul Scheduling

Make sure that equipment is overhauled as necessary, regardless of the standards used to determine such overhaul.

Elect to have major repairs contracted only after weighing all factors concerned.

Five of the standards for determining when overhauling is necessary are:

1. **Elapsed time**—in weeks or months. In other words, machines are taken out of service at specific intervals for overhaul.
2. **Operating time** in hours or days.
3. **Tonnage or yardage handled.**
4. **Inspection.**
5. **Personal judgment.**

Each of these standards has its supporters among maintenance and operating men, though more of them seem to operate on the basis of a combination of inspection and hours operated or tonnage or yardage handled. Where the number of units is large, on the other hand, supporters of the elapsed-time standard point out that a rigid schedule is necessary to permit getting around to all the machines without jams resulting from two or three coming up for overhaul.

A sixth system is, in effect, no overhaul—or overhaul only at long intervals. Under this system, known as unit replacement, overhaul is accomplished by replacing assemblies, such as rear conveyors on loaders, crawlers on shovels and the like, removing the replaced assemblies to the shop for overhaul and storage until another assembly on another machine comes up for replacement.

What might be called a seventh system is practiced at at least one mine where the coal is low, belts are employed, and the difficulty of handling a major breakdown is much greater than in thicker coal. At this operation, each new panel is started with equipment that has been completely overhauled, the crew merely transferring from a worked-out panel and leaving the machines to the maintenance force.

Contract Maintenance

Since outside shops serving a region or a large part of the industry have an opportunity to install more facilities and employ more men with the necessary skills because of the larger volume of business, they are increasingly able to offer major-repair and overhaul advantages, especially to organizations not large enough to support full-scale facilities. Shops now in existence, along with facilities offered by equipment manufacturers, are set up to give speedy, efficient service in overhauling and repairing loaders, continuous miners, shuttle cars and other underground equipment, and bulldozers, small shovels,

engines and similar equipment for strip mines; plus conveyor belts, tires, motors and other components. Bit sharpening, drill sharpening and other service shops round out the list.

Main Shops

Plan to centralize main-shop work where transportation is to your advantage.

Design shops to match individual operations such as, size of operation, type of equipment, type of work done and other factors involved in planning a central shop.

Main shops generally are defined as establishments where work beyond the removal and replacement of parts and assemblies is done. It is difficult, however, to be precise as to what main shops are, since they vary widely in goals, scope of work handled, and equipment. Normally, however, their main business is major repair and overhaul, and to facilitate this they usually include machine tools and other equipment not found in mine shops. On the other hand, main shops can function as mine shops, and they may also, in some instances, include facilities for manufacturing repair parts and even complete equipment units, such as, for example, pumps and shaker pans.

Central Units

Where several mines are operated by a single company, the question arises as to whether to have a main shop at each operation or a big central shop for all. The trend seems to be toward centralizing main-shop work in one plant, especially where good highway and rail connections are available. The advantages include:

1. Less duplication of equipment and facilities, in turn providing an opportunity for adding extra facilities in the main shop without increasing overall expenditure.
2. An opportunity to provide additional repair and maintenance skills because the volume of work is sufficient to warrant employment of certain specialists.
3. An opportunity for increasing efficiency because of the greater volume of work in one place.
4. Less duplication of parts and supply inventories, and consequently a reduction in inventory, as a result of concentration of operations.

Shop Types

Main shops may include types aside from the general overhaul and repair units devoted to machine reconditioning. Examples are: conveyor-belt shops, wheel-reclamation and welding shops, truck-tire shops, minecar shops and so on. Such shops may be separate or may be incorporated into the main shop via separate rooms, bays and the like, and, of course, are warranted only when the volume of specialized work is sufficient to make them practical.

Shop Layout

Since size of operation, type of equipment, type of work done and other factors vary widely, no prescription can be given for a typical main or central shop. A summary of layout and facilities for three specific shops, however, is as follows:

STRIP-MINE SERVICE CENTER—L-shaped shop, warehouse and garage structure, with 66x215-ft garage as the base of the L; next, a 59x32-ft warehouse; and completing the upright of the L, a 59x84-ft machine shop. Thus, the warehouse is conveniently located between the machine shop and the garage. The garage is fitted with 10 rollup doors, and handles the maintenance and repair of all gasoline, butane and diesel equipment and pumps (but not motors), as well as serving as the headquarters for the maintenance of two small walking draglines. Extra engines, and some heavy spare parts, including some rear end transmissions, are kept in a fenced-off enclosure in the garage, which is equipped with a 2-ton hoist on an overhead track.

The warehouse includes a 25x25-ft partitioned section in one corner serving as the electrical shop. Warehouse facilities include convenient outdoor storage for heavy shovel parts while lighter parts that can be brought inside—via a 5-ton chain hoist mounted on overhead rails—are stored on the floor. Bins, of course, are provided for the smaller items.

The machine shop does work for the garage, electrical shop and the field force, and is equipped with three radial drills—one large and two small; horizontal lathe, 20-ft bed, 36-in swing; 12-in lathe, 18-in utility saw, shaper, bolt machine (up to ¾ in), three hand-welding machines, automatically controlled gas-cutting unit, automatic continuous welding machine, two 5-ton and two 2-ton chain hoists. Work done includes building dipper sticks 63 ft long.

DEEP-MINE CENTRAL SHOP—Three-building establishment, all connected with doors wide enough and high enough to permit passage of portable cranes, thus avoiding the use of heavy overhead cranes and hoists; windowless Quonset construction, with fluorescent lighting. Unit functions equipment are:

Building 1, 40x100 ft, rebuilding shuttle cars, loaders and continuous miners; steel work benches, two bench drills, vises, two 300-amp portable welders, gas-welding equipment, air-operated impact wrenches and portable drills, test panel for mercury tubes.

Building 2, 40x100 ft, rebuilding rubber-tired cutters, rubber-tired coal drills, roof drills and other mining machinery; wall-type work benches, special floor-type work bench for repairing shuttle-car wheel units, two welding machines, cable vulcanizer, cable-conductor welder, and 150-kw rotary converter for DC test power.

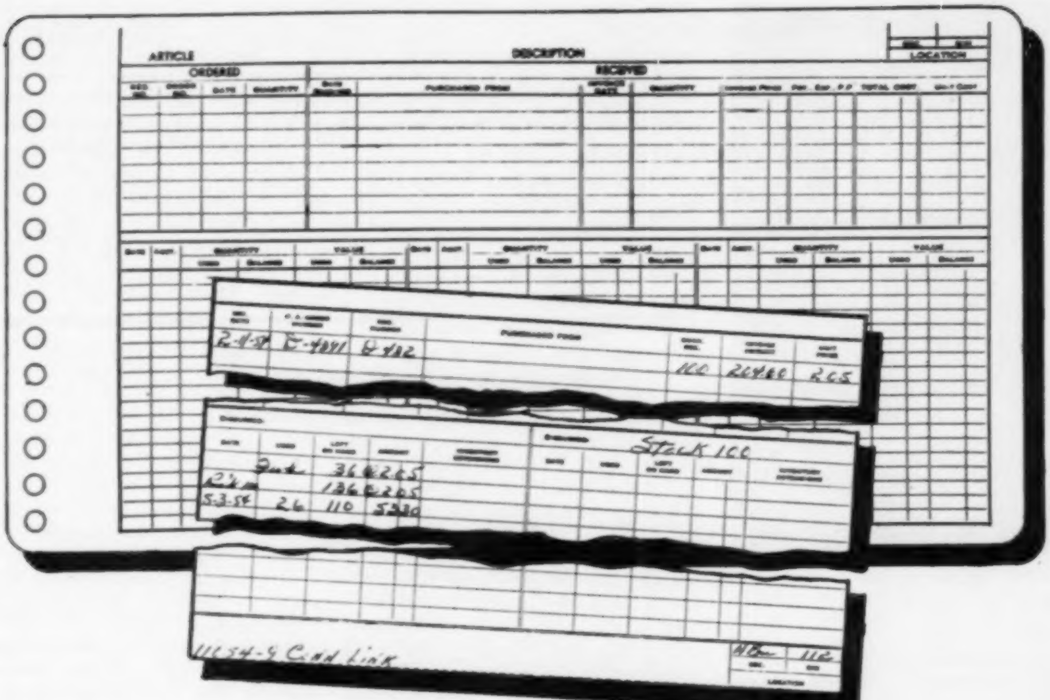
Building 3, double Quonset 60x80 ft plus single Quonset 60x40 ft, building up and machining parts for mines and preparation plants; wheel press; 20-in, 48-in and two 24-in lathes, milling machine, radial drill, 20-in shaper, bolt threader, slotter, metal-cutting band saw, bit cutoff machine, blacksmith forge, air compressor for the three buildings, two degreasers, heating boiler, welding machine, and floor controlled bridge crane across lathe bay; also toilet and shower facilities in 20x20-ft room.

DEEP AND STRIP SHOP—Though designed primarily for the complete rebuilding of underground equipment, one shop also handles certain work for the company's strip operations. Size of the two-story building is 213x95 ft inside, and it includes offices and a supply room. A modified assembly-line procedure is followed, with types of machines assigned to certain bays, and parts removed to service pays for reconditioning before return to the unit. An outside cleaning station is a major contribution to quality and efficiency.

While, as noted, shops vary widely in character and facilities, certain practices and equipment lead to higher quality of work at lower cost. These include: good light, convenient lockers and work benches, special benches and stands for certain work (shuttle-car wheels, for example), supply depots in the shops themselves or at least close at hand, hoisting equipment for lifting and moving anything heavy, including such things as shafts into lathes, and power-operated tools—impact wrenches, etc. Cleaning and degreasing equipment contributes greatly to comfort and efficiency.

Other facilities included in the design of a main shop (see illustration) consist of a foreman's office, supply room, showers and lockers for personnel and a separate section for the electrical department.

While design and shop facilities influence quality of work and efficiency, the need for qualified supervisors and skilled workers also must be considered. A good shop must not only be well equipped but must have men that can do the work. *(Continued on p 174)*



PERPETUAL-INVENTORY SYSTEM provides a running record of supply receipts, quantity on hand, disbursements and costs. Cards shown here are for loose-leaf ledgers (above) and tray-type files.

The Supply Guidebook

COST OF PARTS AND MATERIALS make up a large part of the cost of coal. Surveys by *Coal Age* indicate coal mines spend an average of approximately 85c per ton for supplies alone. The low, usually at the smaller operations, is as little as 40c per ton or less and the high is over $1. With the increased use of larger and more complicated machines, it is quite possible that the average supply cost per ton of coal will increase considerably.

These figures show why supplies are an important item in a good cost-control system (*Coal Age*, April, 1958, p 78) and in turn the need for a good supply system, close inventory control and more detailed reports on the use of parts and materials by machine and by working sections.

An adequate flow of parts and materials is required to keep machines and men working. A good supply system promotes efficiency and lowers cost in four major ways:

1. Machines and men are able to produce more by the elimination of interruptions resulting from lack of parts and materials.
2. Inventory is controlled and kept to a minimum.
3. Parts and materials are received, stored and delivered at minimum cost.
4. Waste prevention and loss of parts and material are controlled.

What is involved in a good supply system and how to get it are the subjects

HANDY DESK equipped with filing compartment is used for parts catalogs.

ACCOUNT NO. LOADERS – 1-101

SHEET NO. ______

REPORT OF MATERIALS AND SUPPLIES USED AT __________ MINE FOR MONTH OF __________ 19____

DESCRIPTION OF MATERIAL AND SUPPLIES USED	QUANTITY USED	UNIT PRICE	SUB-ACCOUNT NUMBERS								
			LOADER #1	LOADER #2	LOADER #3	LOADER #4	LOADER #5	LOADER #6			
TOTAL											

MONTHLY USE REPORTS such as this lend themselves to summaries by account or function numbers, or by individual units to keep track of parts costs.

of the material which follows in this Supply Guidebook.

Control Systems

Establish a good inventory control system, such as, the perpetual inventory.

While the plural "systems" is used in the title to this section, coal mines have largely settled on the "perpetual" system of inventory control.

Perpetual Inventory

Basically, this system shows quantity and cost of units and materials received, quantity and cost of units and materials issued, and quantity remaining on hand at all times. From this, it gets its name "perpetual."

Two of the methods of keeping a perpetual inventory are:

1. Cards on each bin, particularly of the smaller items, on which the records of receipt, disbursement and quantity on hand are kept.

2. Cards designed for keeping in tray-type files, so-called rotary files, or in loose-leaf ledgers.

FILE CARDS—Wide use of the file-card system indicates that it is the handiest and surest. With bin cards or other systems, it normally is necessary to make an inspection or separate notes as the parts and materials are issued to determine if reordering is necessary, and those who have used the bin-card system report that there is a greater possibility of running short through failure to note that the time for reordering has come.

Inventory cards may be made up specifically by a mining company to meet its own needs, or cards, files and systems may be purchased from specialists in business machines and business records, who can, if desired, provide forms and equipment for even punch-card tabulating and record-making where the number and volume of supply items is large.

The accompanying illustrations show two types of cards provided by business-record specialists. One is designed for ledger use and the other for tray-type files. Both show purchases, including, in one type, cost of shipping, and both show cost and quantity received, cost and quantity issued and cost and quantity left on hand after each disbursement. The ledger form also includes a column for the account number to which the supplies are charged. Both also indicate warehouse section and bin number where the item can be found.

RUNNING RECORDS—The perpetual system provides a running record of activity in supplies, and also an easy means of making periodic summaries of use. In some instances, certain types of supplies, such as timber when bought locally as offered, may be excluded from the perpetual system. However, when there are exclusions, it becomes the responsibility of some supervisor or employee to make sure that (a) the items are not overbought, (b) that the quantity is not permitted to drop below the danger point, and (c) that data are supplied for the periodic supply-use and inventory reports. Most mines prefer to have everything in the system.

INDICATORS FOR REORDER—Certain types of cards are designed to permit the use of "flags," or colored tabs, to facilitate reordering and the compilation of periodic reports on use of parts, supplies and materials. A green plastic tab on the bottom of the card may be slid to the center the first time an item is issued in a monthly or other report period, and a red tab on the opposite side also may be slid to the center as an indication that the item is to be reordered when the next weekly requisitions on the purchasing department are prepared. The flags make it unnecessary to check each card for either preparation of the distribution report, or for reordering, thus saving considerable time and making it easier for the supply clerk.

Supply Receiving

A new receiving system, in which all necessary papers are prepared in a single writing by means of a portable register, is now being used by at least one company to expedite the receiving operation (*Coal Age*, September, 1957, p 73).

This system eliminates delays in reporting receipt of shipments, which result in the delay of payment of invoices, with the possibility of missing out on discounts.

The "Receiving-Delivery Ticket" consists of four parts:

Part 1, the invoice clerk's copy (white), with freight or express bill attached.

Part 2, the cost clerk's copy (green).

Part 3, the requisitioner's acknowledgment (blue).

Part 4, the requisitioner's copy for filing (salmon).

Physical Inventory

Whatever the control system employed, it should be supplemented by an actual physical inventory. The practice varies between 6 mo and a year at most mines.

Even at small operations, an accurate record of receipts, cost and use is essential for wise and economical use of supplies, and while the perpetual or other good inventory system requires some paper work and the assumption of responsibility by some person, it can save both money and production time in the same proportion as in larger operations.

Use Records

Compile detailed reports on the use of parts by each major machine.

Submit monthly distribution reports, to mine and operating management.

Though it requires extra paper work, there is a growing tendency to go beyond the standard "supply-distribution report" and require more detailed reports on use of parts and materials by machine and by working section for the purposes listed in the preceding paragraph. The standard distribution report, usually prepared monthly, shows supplies charged to classes of equipment, such as, shuttle cars, and to mining functions, such as ventilation, timbering and the like. For convenience, each equipment class or mining function is provided with an account number.

ACCOUNT NUMBERS—Where account numbers are used, some hold that the daily or other delay reports (see the Maintenance Guide-book in this issue) provide—at least by inference—sufficient information to determine whether supplies are being used properly and economically. Those who are adopting the more detailed system argue that definite and positive information is a necessity to prevent waste and loss through abuse and carelessness, particularly in view of the rising cost of everything that enters into mining.

ORDER FORMS—Whatever the system, order forms, reports and records are essential for the proper evaluation of supply use. To start off with, nothing should be issued without an order, properly signed, stating what is wanted and where it is to be used. This applies even if the item is for current use, such as, timber, or is to go into, say, a section parts depot to replace some item used in maintenance. And for a check and appropriate action, summaries of supply use should be prepared at regular intervals for the information and use of mine and operating management.

MONTHLY DISTRIBUTION REPORTS—The monthly distribution report previously referred to and prepared by account number is one form of report to mine and operating management. Where more detailed data are desired, the form or forms may be expanded to show items charged out to each machine, to each working section and to each general function, such as pumping, thus providing a better opportunity for determining whether abuse is running up parts cost for a particular loading machine, as an example, or whether certain sections are taking a larger-than-normal supply of timbers, perhaps indicating waste.

SPECIAL REPORTS—Aside from reports derived from the regular requisitions, special reports may be required of certain officials and mine employees. For example, a single carbide-tipped cutter bit can cost $1.25 or more, and therefore, some operators feel that it is in order to ask the section foreman or machineman to report daily on number on hand at the start of the shift, number received for replacement, number sent out for grinding, number destroyed in operation, and number on hand at the end of the shift. Similar records could be required for other small and relatively costly items, such as, roof bolts, steel ties and the like.

Since they are required to report on use, the men responsible naturally would take care to prevent loss, and if the record showed excessive destruction, for example, there would be an opportunity to check to find out why. Incidentally, such records also would reduce the number of small items, such as, cutter and drill bits, that would find their way into the railroad cars, particularly if the responsible men were required to turn in the worn-out or broken items.

To wrap up a detailed record system, it naturally should show transfer of certain materials, such as, steel ties, from one working area to another, thus guarding against, among other things, possible loss through carelessness or buck-passing. And if such things as timber were salvaged for use elsewhere, the records should show how much came out of a particular section and where it went as a means of gaging, among other things, the effectiveness of a salvage program.

Practice Trends

INCREASED COST of parts and materials reflected in strong emphasis on close inventory control.

GOING BEYOND the standard "supply-distribution report" and requiring more detailed reports on the use of parts and materials by machine and by working section growing as a means of more effectively controlling cost.

TREND TO CENTRAL SUPPLY HOUSES to serve multimine operations gathering momentum for economy reasons. Advantages include reduction in total inventory and opportunities for buying supplies in larger quantities at reduced prices.

Inventory Control

Keep an adequate supply of items on hand that are essential in controlling the cost of coal production.

Regulate supplies by reordering on time. Don't permit bins to get empty.

Select the type of warehouse that suits your individual mine.

The question most often asked about supply inventory is: "What should be carried in terms of dollars and cents?" Actually there is no one answer. Inventory, if too high, means that money will lie idle. On the other hand too low an inventory can mean increased production delays and higher production costs. Among other things, the level of supplies at individual mines depends upon mine location and size. Inventories range from as little as $25 to $30 per ton of daily capacity up to $150 or more per ton at mines remote from manufacturing and distributing centers. The average appears to be in the neighborhood of $50 to $60 on hand per ton of daily capacity.

Control Factors

Under coal-mining conditions, the inventory level involves a fair amount of personal judgment based on experience and an analysis of parts and supply use in relation to time for normal replenishment. Some of the factors involved in arriving at a solution include:

1. Cost of item or a class of items in relation to production cost increases incurred if the item is not on hand when needed—for example, spare armatures or motors. For instance, how much, at the most, would a rotor failure on the main shaker-screen motor involve in payments for non-productive labor, for power for ventilation and pumping during the production interruption, and so on? And would the cost be reduced if a complete motor was on hand instead of only the rotor? Or should the possibility of a stator failure be the controlling one and thus dictate keeping a complete motor ready for replacement?

In all these, it is assumed that the

tonnage loss could be made up at a later date and that the extra cost on the breakdown day is the major factor, though if the breakdown occurred near the end of the shift the loss might be reduced by better preparation in the mine for the following shift and consequently a higher tonnage and higher efficiency on that shift.

2. Rate of use in relation to time required to reorder and get delivery of replacements. Experience normally will indicate the rate at which, say, controller fingers of a certain type are used. If new supplies could be secured in a month, then the maximum on hand at any one time theoretically would be a month. However, it may be considered desirable to have an additional reserve, which becomes largely a matter of judgment. Or, the total use in, say, 6 mo, might be so small that it would pay to keep that much stock on hand to avoid the extra clerical and other effort involved in ordering more frequently. Also discounts for volume may be a factor in quantity ordered and consequently the total on hand at any one time.

3. Central warehousing vs. warehouses at individual mines. Where one company operates several mines, it normally is considered more economical to operate one central warehouse provided certain conditions exist. These include:

A. Reasonable distances from central warehouse to mines to keep down delivery time.

B. Good highways and good trucking facilities to permit fast deliveries.

Where these conditions exist, central warehousing, as noted, is considered feasible and economical, except for certain types of supplies, such as, timber, rail and the like. Of course, a certain volume of other parts and supplies must be kept at each mine and, in fact, at each deep-mine or pit face, to facilitate maintenance and prevent operating delays arising out of such things as lack of timber, etc.

A major advantage of the central system is reduction in total inventory because it is not necessary to duplicate each item at each mine, particularly the larger, more-costly units, since, with fast delivery, a small number of, say, armatures can serve the several mines. Otherwise, it might be considered necessary to keep one at each property.

4. Cooperative stocking. Where a part or a component is large, costly and requires considerable time to repair or, if completely wrecked, must be manufactured from scratch, it is possible for a group of companies in an area to buy one such component or part and rotate it around as needed. Thus, several companies—for example, a group of strippers using identical machines—are protected against major production losses with a minimum outlay for spare parts of a key and costly nature.

5. Independent warehousing. Where manufacturers, their agents and independent supply houses have branch or main establishments close to the coal fields, maintain stocks of the desired items and provide quick delivery, it is possible to use them as the source for many items, thus cutting down on both inventory and on company-owned warehousing facilities.

6. Price trends. If one is willing to risk the hazards of estimating future trends, it may turn out to be desirable to run up the inventory of parts and supplies—at least in part—to offset expected price increases, or to curtail purchases in anticipation of decreases. A more-rare occasion for perhaps increasing inventory is anticipation of decreased availability as a result of strikes, government control of critical materials, and so on.

Storage and Handling

Plan storage layout for efficiency, convenience and protection.

Include in supply-house facilities bins for small and medium-sized items, hoist where necessary, push-type carts and so on.

Type, size and cost of specific items normally dictate methods for receipt, storage and issuance. Thus, depending upon these factors, both enclosed and open storage are employed at mines. Enclosed or covered storage includes both regular supply buildings and also sheds for certain items requiring less protection.

Open or yard storage is satisfactory for timber, steel ties, rail and the like including heavy equipment items that are not appreciably affected by rust and other deterioration as a result of exposure to rain, snow, dust and the like. Where the items are made, for example, from copper and lend themselves to theft, enclosed storage normally is dictated to prevent losses of this type. Shed storage may be desirable for pipe, structural shapes, plate and the like to prevent excessive rusting and also avoid difficulties with snow and rain in storing and handling. However, shed storage rules out, in most instances, the use of mobile cranes in handling such items, and the ability to use such equipment may outweigh the disadvantages of open storage.

Storage Layout

While the storage layout will vary from mine to mine, the plan shown at the start of this Supply Guidebook illustrates some of the basic principles involved in achieving efficiency, convenience and protection. In this instance, the shop is near the supply house and thus a separate shop supply is not required. The principles illustrated include:

1. Receiving and loading dock completely surrounding the warehouse. This is a practice that can be followed if desired, but it may not always be necessary to surround the supply house with docks, though provision should be made for sufficient dock space both for receiving and for loading mine equipment. The docks in the setup illustrated are at the right height for receiving material from railroad cars or trucks, and for loading materials into mine equipment without excessive lifting or lowering.

2. Open storage planned so that as heavy material is unloaded it can be placed so that it is convenient for loading into mine equipment. Roads are located so that mobile cranes can be used for unloading railroad cars or for lifting heavy items out of storage into mine equipment. These same roads permit unloading such items as mine props and timbers directly to the mine trucks if desired.

3. Use of power-operated handling equipment. The mobile crane, with various attachments, including clamshell for sand and gravel, and fork for props, rails and the like, or other mobile handling units materially reduces labor and also the hazards involved in handling heavy parts and materials. With a fork-type grab, for example, two men can load a car of ties in less than 1½ hr. Aside from cranes, mobile handling units include motorized wheelbarrows, motorized high-lift bucket-type loaders and carriers, high-lift fork trucks, crane trucks and so on.

4. Open platform with inclined ramp provides open storage for certain parts and materials and also makes it easier to get equipment, such as, shuttle cars, loaders and the like out of railroad equipment and down to mine-track level. Handling of heavy items on the platform can be done with the mobile cranes, or the platform can be equipped with crane rails and a hoist. An alternative is a crane track extending out of the supply house to the platform both for handling materials on the platform, or for moving them inside to floor storage. The plan illustrated also shows an open plate storage with traveling crane and hoist.

Plates are stored on edge between stanchions.

Supply-House Facilities

Supply houses include both bin storage for small or moderate-sized items, and floor storage for heavier units. The floor-storage facilities at one new supply house include a basement for cool storage of rubber-covered cable, conveyor belts and other rubber items. Access to the basement is by 25-ton hydraulic lift, large enough to handle even the heaviest reels of cable and belt, which can be rolled on and off.

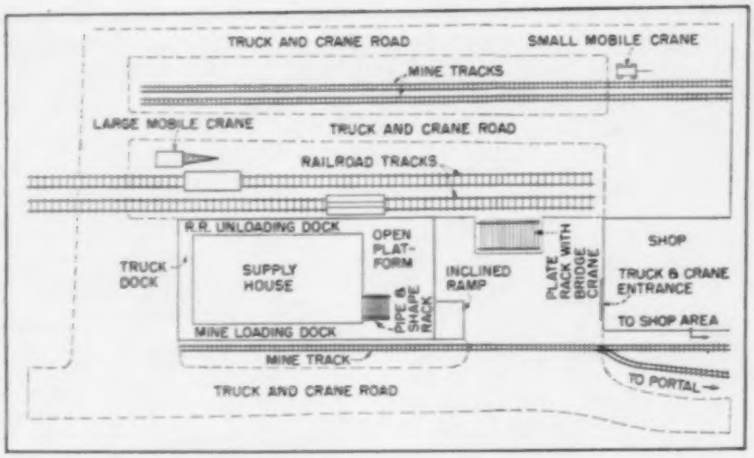
Some supply houses include a monorail and hoist for handling heavy units into and out of the floor-storage area, and storage facilities for such heavy items, include, in addition to open floor, racks for, say, spare armatures.

Other facilities which have proved successful in simplifying the handling of supplies in warehouses include: sectional steel bins with adjustable shelves; drawer-type and rotating bins for small items; clear plastic chest and drawer units for miniature units; shafts and reels mounted on walls or stanchions for convenience in paying out and measuring cable, hose, rope, etc.; peg racks for V-belts and similar items; and platform-top push trucks for moving items to and from bins, especially if the warehouse occupies a rather large floor space.

If bins are built up higher than eyesight level or arm's reach, trolley or wheeled ladders or steps save time and reduce the possibility of injury. One wheeled step, for example, includes springs which give when a man puts his weight on the steps and thus provides solid footing.

Light should be ample to read tags, nameplates and the like, and the sources should be placed so that it is relatively easy to see into the backs of shelves or bins, especially those high up.

Other ideas employed to facilitate storage and handling include: Easy access to bins, for safe and quick disbursement of parts by the use of permanent stairways and balconies. Monorails equipped with hoists and armature racks mounted on wheels (see illustration) save space and facilitate handling of heavy parts.



CONVENIENCE, EASY ACCESS AND PROTECTION feature yard designed for truck and mobile-crane operation with receiving and loading docks on three sides.

Allocation of Stocks

Provide necessary parts and material at or near the point of use.

Make studies to determine type and quantities of such supplies.

Even where only one mine is involved, the satellite principle of stock allocation is necessary to keep production interruptions to a minimum. In other words, stocks of frequently used machine parts, as an example, should be kept close to or in the pit or underground section for the use of the section or pit electrician or mechanic. Otherwise, major delays may occur as a result of having to send outside or to the main supply house for a needed item.

EQUIPMENT REQUIREMENTS—Type of unit and experience indicate the types of parts and materials to be kept in such satellite pit or face depots. Normally, replacements for such stocks are charged to operating cost when they leave the main supply house. If it is desired, as discussed previously, to keep accurate use records, the section or pit electrician or mechanic can file reports showing use of items by machine number, thus enabling operating management to keep track of where parts and materials go. Rather than a separate report, the section mechanic's or electrician's daily delay and repair report (see the Maintenance Guidebook) can show what items are used and where.

CENTRAL WAREHOUSING SYSTEM—Where two or more mines are involved and the central warehousing system is employed, allocation might be along the following lines:

1. Principal stock of repair parts at the central warehouse.
2. Subsidiary stocks at the central repair shop, provided it is not adjacent to the central warehouse.
3. Subsidiary stocks at the mine shops.
4. Section stocks in the working sections or pits for running repairs and maintenance.
5. Stocks of ties, timbers, roof bolts and similar items at the individual mines, since it is more convenient and less costly to have such materials delivered directly to the mines for storage and distribution rather than rehandling them from a central point. In fact, even where only one mine is involved, it may be more convenient to provide separate facilities for receiving, storing and distributing (a) machine parts and smaller items, and (b) larger, bulkier items used every day the mine runs.

Special Supply Houses

Design and locate powder houses in accordance with state and federal safety authorities and recommendations of the Institute of Makers of Explosives.

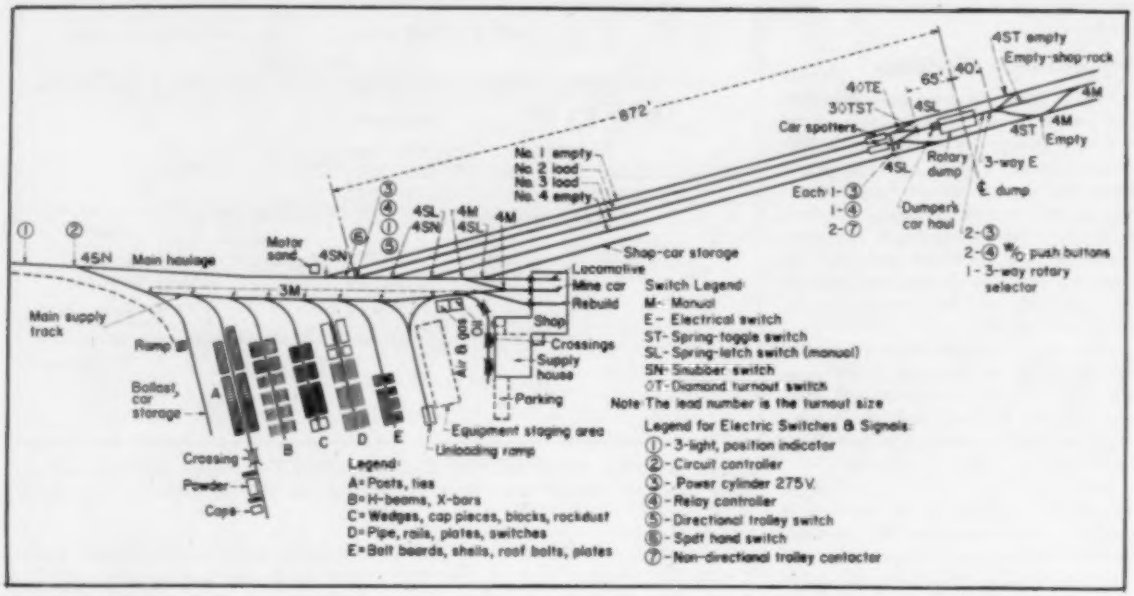
Set oil houses and oil-storage facilities apart from other surface units and build them of fireproof materials.

Provide sand houses with adequate capacity and locate them so receiving, drying and dispensing are controlled by gravity, if possible.

Supply facilities falling into what might be termed the special class are: powder and oil houses, sand-storage and drying establishments, and even portable or semi-portable pit or mine houses.

Design and location of powder houses is a matter of following the recommendations of state and federal safety authorities and the Institute of Makers of Explosives. Factors to be considered with other types include:

OIL HOUSES—There is good reason



SUPPLY YARD has tracks running to areas assigned to specific items. Loading is simplified with power crane. Four mine-car tracks permit storing or blending of raw coal. Supply house and shop are strategically located.

QUONSET BUILDING SERVES AS SUPPLY HOUSE at one coal-mining property. Large doors permit trucks to enter building to load and unload.

for putting oil houses and oil-storage facilities apart from other surface units. Oil and grease are, after all, flammable. However, there is no reason why they cannot be located for easy receipt of supplies either by truck or rail. As a matter of fact, convenient, clean and safe facilities for dispensing are as much factors in oil-house design as storage.

Designs most nearly meeting these objectives include: steel and concrete construction, racks that hold drums in proper position for dispensing, hoists or other mechanical facilities for handling drums, and provisions for catching drip and spillage. Fixed racks should be provided with inclined ramp rails to permit rolling drums up to position, unless chain hoists are used. Chain hoists, incidentally, make it easier to replace drums without handling of others, as do tilting-type racks with castors, which may be pulled out of position, run to the storage area and tilted to permit taking off the drum, after which the process is reversed to put a new drum into position.

An example of a well planned oil house is shown in the accompanying illustration (Texas Co., "Lubrication of Coal-Mine Machinery"). Note that oil drums are delivered on a platform at truck-bed level. After drums are emptied they are rolled to the end and under the top rack to the outside.

SAND HOUSES—Terrain and otner considerations affect sand-house design and location. If possible, the facilities should include storage for a specified number of truck loads. In hilly country, where sand is received by truck particularly, it may be possible to build the road up on the hillside so that trucks can dump directly into the bin.

The preceding comments presuppose gravity flow from the wet storage bin to the drying stove or stoves, and from the stoves or dry-sand bins to the locomotives, sand cars or bore-hole to the mine-bottom. This gravity flow materially reduces labor in all phases of receiving, drying and dispensing sand, and this saving may warrant a substantial investment in bins and gravity-handling facilities which, in some instances, are almost or completely automatic.

Though not yet possible in too many mining areas, sand-handling facilities may be eliminated completely by depending upon outside suppliers for drying and delivery. At one operation, the custom drier delivers the sand in oil-type drums ready for movement into the mine.

PORTABLE SUPPLY HOUSES—Under certain circumstances, a "portable" supply house becomes quite convenient in addition to providing protection and promoting order in dispensing supplies—particularly machine parts. One circumstance is stripping where frequent moves are made from one location to another. Another is deep mining of the contour type, where the main opening keeps moving around the hill. Under

like. Special crawler-mounted pullers and carriers also have been built for

REELS FOR CABLES facilitate storing, handling and measuring out pieces.

MECHANIZED EQUIPMENT speeds unloading of roof-bolts from truck into cars and eliminates the need of adding extra men to the detail.

such circumstances, a number of mining companies have bought small prefabricated buildings and mounted them on skids or trucks for towing from one location to another.

Supply Delivery

Provide facilities for supply delivery on the surface and underground for quick delivery with minimum labor.

The motor truck in its regular form is the work horse in supply and delivery on the surface. In its special forms, especially at stripping operations, it includes grease trucks—usually designed for actual application of the grease at the point of use as well—fuel trucks and utility trucks. And at some operations, the final stage in storage and delivery of explosives—at strip mines, for example—is handled by small rubber-tired units designed for towing on the bank by tractor, relieving the regular truck for other duties.

Delivery Schedules

Delivery between supply house and shop, for example, where the two are not too far apart and are connected by a hard-surfaced roadway, may be handled by hand-pushed lift cranes, motorized cranes or special motorized flat-bed trucks.

Where trucks are used to deliver supplies from a central supply house to more than one mine it is important that order and delivery schedules be worked out. As an example, requisitions from the various mines should arrive at the supply house at a designated time to permit the supply clerk to fill the orders before the supply crew is due to arrive. When the supply crew arrives supplies should be ready for loading and delivery to the mines as scheduled.

BOREHOLE SUPPLY—One new wrinkle in speeding up delivery to shops or distribution facilities underground is the supply borehole. One such borehole (*Coal Age*, March, 1956, p 94) is fitted with a 24-in casing (large enough for an emergency escape-way) and a headframe with a 5-ton hoist. Spotted at the right place, a borehole sometimes can save a long underground trip for parts and other small items.

Underground Delivery

Where mine cars are employed to haul coal, the same track is used for delivery of supplies—perhaps to the face or, if trackless mining is the rule, to the point where the rails end. Even with belt haulage, convenience in handling supplies and men has led a number of operators to put supply tracks alongside the belt conveyor—or in a parallel heading. Battery locomotives may be equipped for pulling the equipment on such auxiliary track systems to avoid having to put up trolley wire. And in some instances, rubber-tired tractors and trailers are employed to take in supplies, eliminating track completely. With either system, the added convenience and saving in time and labor is held to warrant the installation of the track or the preparation of the special roadway for the trackless battery units.

Where belts are installed for haulage, especially single panel units, they may be provided with reversing facilities for movement of supplies back to the face. In some instances, at least, special inching and jogging controls have been provided to facilitate handling long crossbars and other items without hazard to men or to the belt and conveyor.

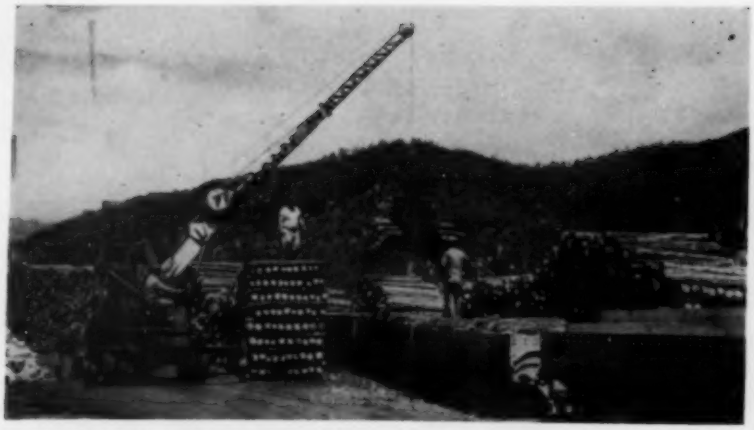
Facilities for delivering supplies to the faces of rooms equipped with conveyors include:

1. Dolly trucks running in shaker lines.

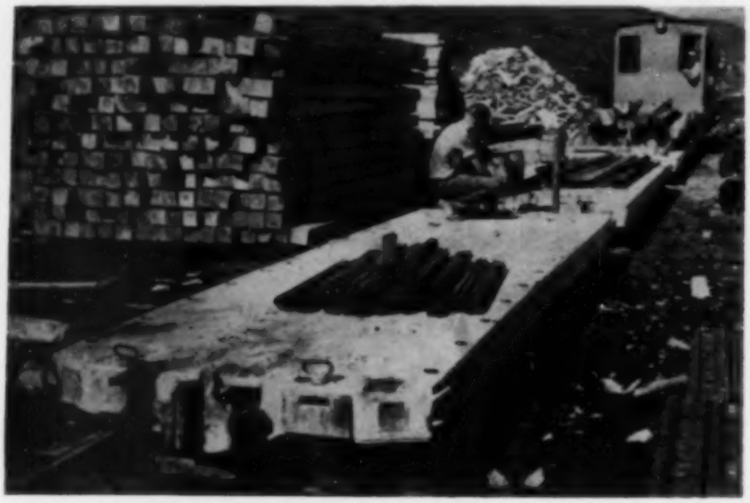
2. False pan lines, or lines of pans alongside the operating line, which are loaded with supplies and pulled up as the main line is extended, the face pan going into the operating line and the supplies to other face operations. At the same time, a new pan is added at the outby end and loaded with supplies until the place is halfway up, at which point the loaded line will complete the place.

In pitching places, small hoists may be included in the equipment at the face to pull timber and other materials up from the track on the gangway below.

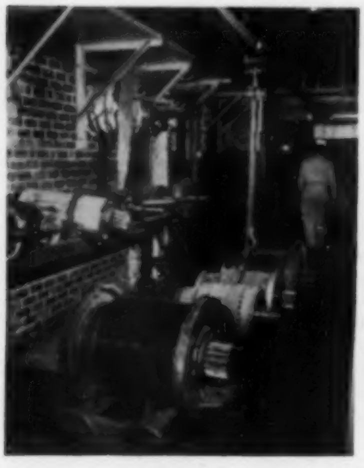
MOBILE UNITS—For the most part, unless pitch or some other condition prohibits, the mobile unit operating either on or off the track is the most efficient and flexible unit for supply delivery. In trackless areas, the mobile unit may be a shuttle car, though using a shuttle car on the working shift may result in interference with production. If supplies are delivered on the off-shift, the shuttle car may well double in brass. And if crawler trucks are used for moving shortwalls, these same trucks may also be employed for handling heavy units, such as motors, drives and the



MOBILE CRANE with various attachments handles heavy materials in the supply yard and can unload a car of ties in less than 1½ hr.



VERSATILE FLAT-BED TRUCKS facilitate supply delivery to working sections in coal mines. Note diesel-locomotive being used in supply yard.



MONORAIL AND ARMATURE RACK saves space and facilitates handling heavy parts.

24-IN BOREHOLE cuts the time involved in getting small parts underground.

like. Special crawler-mounted pullers and carriers also have been built for moving drives and handling materials.

The extra advantages of special equipment, including availability at all times, design for handling materials and the like, have led, among other things, to a substantial growth in such equipment as battery powered tractor-trailer units, especially in trackless areas. Some mines also have used the equivalent of a straight truck with a battery for power.

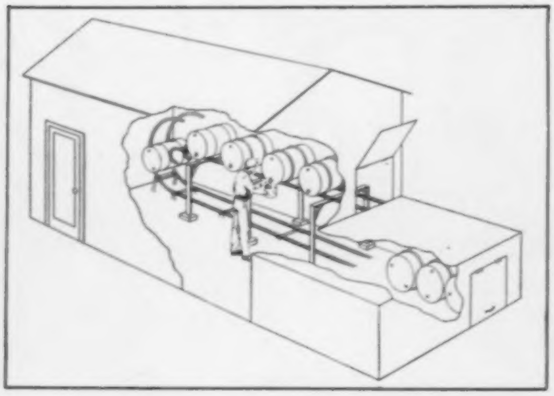
For rail delivery, the mine car, as noted, still is the mainstay. However, special cars and trucks provide a number of advantages, including better design for loading, unloading and protection of materials and supplies. An example is the low-height flat-bed car with steel deck and holes all around for stakes, which lends itself to handling almost any shape or size or material or part. Such cars are used on moderate-pitch slopes as well as on the flat. In tandem and properly loaded, such cars also can move rails and long timbers, though the special rail truck still is a standard item at most operations.

Other special cars which a number of operations have found advantageous include the following:

1. A utility car with a cab for the snapper equipped with plastic windows, and compartments for such items as steel ties, miscellaneous track and trolley supplies, coal augers, roof bolts and the like.
2. Sand cars especially designed for the service, including sides low enough for easy unloading to sand boxes.
3. Enclosed powder cars with sliding doors and insulated couplers.
4. Special insulated detonator cars with steel doors, wood and rubber lining, and compartmented drawers.
5. Special ballast cars with bottom doors designed for spreading ballast in the track.

Special handling facilities at unloading or transfer stations underground can materially speed up the job and reduce the hazards. Oil drums, for example, may be lifted off trucks or out of cars by a small chain hoist and run back into the underground depot on a monorail. Similar facilities also may be installed for handling timber, roof bolts and other bulky, lengthy or heavy materials and parts. Handling is facilitated by bundling or typing the materials, such as, timbers, to make it easier to hook onto them with the hoist. In fact, some companies ask that lumber and certain other materials be bundled and strapped by the supplier to facilitate handling all along the line. Properly designed, underground stations of this type make it easy to unload and store materials until the face equipment is ready, then facilitate reloading for distribution.

OIL-HOUSE OPERATION is facilitated by such equipment as these castor-mounted tilting racks.



TYPICAL LAYOUT OF AN OIL STORAGE HOUSE permits easy handling of oil drums by one man.

Preventing Waste and Loss

Reduce waste and loss of parts and materials by setting up rules and standards and following through.

SUPPLY CAR EASES HANDLING of conveyor pans, parts and supplies in thin seams and reduces emergency repair time by getting parts to the face quickly.

There is no particularly easy road to reducing waste and loss in parts and materials, but results can be achieved by, among others, the following methods:

1. Good Records—Where supplies go and how much (see "Use Records").

2. Education – Some companies have found, for example, that a display of certain supply items, each tagged with its cost and accompanied by some pertinent words by the superintendent or foreman, brings home to men the costs involved in loss or carelessness and consequently leads employees to handle materials and parts more carefully.

3. Prevention of Machine Abuse—This is largely a matter of training both operators and supervisors in how abuse results in breakdowns, lost time and an increased cost for parts.

4. Rated Voltage—Along with education of operators and supervisors, the rule should be rated voltage at the terminals of all machines, since less than rated voltage inevitably results in an increase in machine breakdowns, with attendant loss of time and increase in parts consumption.

5. Protection—Moisture in cement, coal dust in an open container of oil, and a bundle of roof bolts thrown along the rib and covered with loose coal are all examples of loss through failure to protect materials and supplies. The moral is enclosed storage for materials or parts subject to weather or water damage, enclosed containers for lubricants all along the line from receipt to point of use, and specific places for everything in the supply line—for example, special supply delivery points, with cabinets, chests and the like as necessary in every section for receiving and storing parts and materials. Indiscriminate dumping inevitably results in loss.

Salvage

The extent of salvage operations depends upon the value of the part or item in relation to the cost of getting it out and, if necessary, reconditioning it. Expending \$2 on labor to recover something worth only \$1 in the first place is, of course, out of the question. However, in view of the cost of materials and supplies these days, a carefully considered salvage program can result in major savings.

Education is a major ingredient in an effective salvage operation. In other words, if men are encouraged to form the habit of picking up anything they see lying around and turning it in to a specific salvage station—on each section, for example—rather than walking by or, even worse, pitching things into the gob without thinking, the company benefits not only by the return of usable parts and materials but also from the scrap value of worn out items. Of course, each foreman should check on loose and misplaced materials constantly.

Certain items lend themselves to the use of organized salvage crews—for example, crossbar and post recovery. Equipped with mobile pulling units involving wire lines, chain slings and winches, such crews can, where safety considerations permit, recover several times their wages in posts and bars—as well as ties, rails and so on. A few mines have even used mine-detector-type equipment to find carbon-dioxide coal-breaking shells, steel ties and like buried in loose coal or gob in working places.

PROPER STAFF—The important requirement is that some provision be made for handling each function, and this is

Practice Trends

SAFETY EDUCATION AND TRAINING, the first a continuing process and the other consisting of spot programs for specific needs, must be major concerns of top management in shaping an effective safety program.

The Safety Guidebook

SAFETY, like other matters of concern to management, lends itself to a planned approach. The steps in planning are as follows:

1. Organize for safety, employing all available skills to the fullest degree and enlisting all interested parties.
2. Train and educate for safety, using planned programs for workmen, supervisors and management.
3. Maintain the physical features of the mine and its surroundings in the approved manner to eliminate conditions leading to accidents.
4. Keep interest alive by a continuous program of safety incentives, any of which may be scrapped without remorse the minute it loses its appeal.

BETTER ILLUMINATION promises improved safety by facilitating inspection and by throwing light on hazards encountered in face areas.

Safety Organization

An adequate staff of safety experts, unburdened by extra duties, is a top requirement in achieving maximum safety.

Safety committeemen of the local union should be consulted on matters of safety.

The type of organization depends upon the job to be done. Within the company there are a number of functions to be performed. Someone must head up the program, someone must inspect the workings, the ventilation system must be patrolled, training must be conducted, and so on. If the company is small all these responsibilities may be handled by one man. In larger companies operating a number of deep and strip mines and cleaning plants the safety department may include one or more qualified men to fulfill each of the functions that must be served.

PROPER STAFF—The important requirement is that some provision be made for handling each function, and this is another top-management exercise in bringing together the skills available within the official family and the jobs to be done. The staff of the company safety department should be neither too large nor too small. An overweighted safety department may become a "dumping ground" for a number of other activities for which a natural home cannot be found in other company departments. The result is a loss of enthusiasm for safety and these losses are doubly difficult to make up.

The understaffed safety department, on the other hand, may miss too many good bets in safety because of difficulty in maintaining proper coverage of its legitimate responsibilities. The best way to get the proper manpower, in quantity and quality, is through sincere top-management consideration of the matter. A top-notch safety department is worth the effort because it pays off in better employee and public relations, reduced labor turnover and increased efficiency, in addition to its primary function of accident prevention.

EMPLOYEE PARTICIPATION—Employee safety committees should be included in the table of organization. Their recommendations concerning hazards should be heeded and acted upon, their suggestions should be carefully weighed, and their active support in training and promotion ventures should be solicited.

An excellent example of how such cooperation pays off appears in *Coal Age*, March, 1957, beginning on p 64. The result was that a large mine was able to complete a full year without having a lost-time injury or fatality caused by roof falls.

JOINT ACTION—Above the company level a need may exist for an organization to promote safety for a group of mines or companies having similar safety problems. A full description of an organization of this type appears in the September, 1955, issue of *Coal Age*, beginning on p 58 and featuring the highly successful operations of the Indiana Joint Committee for Coal Mine Safety. This was a truly cooperative effort.

Wholehearted support of local safety associations and institutes by the company and participation of company safety officials in the affairs of Holmes councils and chapters, the National Mine Rescue Association and National Safety Council, for example, are proper extensions of top-management's interest in safety. These, too, represent organization for safety. Of course, cooperation with federal and state safety and inspection authorities is an integral part of any safety effort.

Practice Trends

LIGHTING—Approved mine lighting systems, for use at the usual face-voltage ratings, should raise undergroupd illumination to levels approaching those in other industries, thereby improving safety performance.

ROCKDUSTING—Slurry-type rockdusters now are availalbe for direct mounting on face machines, or in self-propelled units for wet or dry rockdusting.

FACE VENTILATION—Auxiliary ventilation, especially with continuous-mining machines, is being reevaluated in view of special problems created by faster advances.

ROOF BOLTING—Bolt-tension-indicating roof plates are coming into increasing use to provide visual check on status of bolts.

Operating Reports

Emergency Action—How to use, maintain and distribute Self-Rescuers. *Coal Age*, August, 1957, p 69.

Eliminating Roof-Fall Accidents—Six-step program permits full year of operation, for an output of 1,427,000 tons, without a single roof-fall injury. *Coal Age*, March, 1957, p 64.

Mine Explosions—How they happened, with recommendations to prevent repetition. *Coal Age*, May, 1957, p 96, and *Coal Age*, April, 1958, p 30.

Fire Control—Equipment, organization and training are the elements required for effective fire-fighting. *Coal Age*, July, 1957, p 66.

Dust Control With Continuous Mining—What the problems are, what is being done to meet them and what is needed for future progress. *Coal Age*, July, 1956, p 56.

Training and Education

Promote continuous safety education to keep the subject alive in the minds of all employees.

Conduct target-centered training programs to improve safety in specific phases of mining.

The terms training and education are not synonymous. They are two distinct functions, differing in scope and in emphasis. Safety education is a broad program designed to convince workmen and supervisors of the waste inherent in a high accident rate, and of the real values in high safety performance. Safety training, on the other hand, usually takes the form of a hard-hitting direct attack on particular hazards, like 100% training in accident prevention. Safety education is a continuous process, while safety training, on any particular subject, begins, proceeds and concludes in scheduled well-planned manner.

The educational mission can be carried out through the use of a company publication (if thoughtfully prepared), a well-planned poster campaign, word-of-mouth advice and management example. The safety display board near the lamphouse or at the entrance to the property can be a big help here. If it can't be kept timely, however, and if it isn't kept reasonably clean and in good repair, it might better be removed from sight.

TRAINING FUNDAMENTALS — A need for training may be indicated by a general rise in frequency or severity rates. Or the number of injuries chargeable to a single cause—haulage, for example—may spurt upward. Next step is to select the training material, basing the selection upon the recognized needs of those to be trained. If an outside agency is to conduct the training, these instructors and company representatives should

EMERGENCY TOOLS and supplies to speed recovery work are cached in specially-designed underground rooms. Keys to the rooms are entrusted to safety officials.

CAREFULLY-MAINTAINED rescue equipment must be ready for instant use and should be reconditioned immediately after it has been used.

FUSIBLE LINKS melt in event of a substation fire to close doors and seal off fireproof station from rest of mine.

LAYOUT of this drainage system permits reversal of normal water flow to fight fires deep in the mine.

Preparedness: Key to handling emergencies effectively and quickly

meet to examine the content to make certain it fills local needs.

Course material should be severely limited to the interests and needs of the trainees. In a course for cleaning-plant personnel, very little reference need be made to the fact that roof falls and haulage are the major causes of accidents in the industry. They are more concerned with safety on stairs and ladders, and with such other matters as falls of person, open machinery, dust hazards and electric shock.

PROMOTING ATTENDANCE—The problem of getting men to attend the training sessions can be a tough one. The safety committee can be of great help here, if the committee has been consulted early in the planning stages. In striving for 100% attendance at accident-prevention training sessions, conducted by Bureau of Mines instructors, company officials will achieve maximum results by working closely with district officials.

Beyond this basic training area there is advanced training work any company may profitably pursue. Periodic training in advanced first aid and mine rescue may be offered to selected men and supervisors. One important goal of this training should be the development of new instructors.

Training, though, is not an end in itself. The clincher is in management's follow-through, which insures that results match the effort.

Maintaining Physical Plant

Set up standard procedures to guide safety and production officials in correcting hazards discovered during inspections.

Vigilance is the keyword in maintaining a mine, cleaning plant or strip pit in safe condition. A sluggish track switch in the mine, "soft" brakes on a strip-mine haulage truck, dust accumulations in the preparation plant—all these are examples of potential accidents that can

qualified success in all quarters. The privilege of wearing a white safety hat

Maintenance *(Cont'd from p 160)*

COMPETENT DIRECTION for drivers and operators at strip mines is needed at truck ramps and spoil areas to keep drivers out of trouble and to warn others.

CLEANLINESS, good lighting and safety-coded paints improve safety in preparation plants. Frequent inspections and scheduled maintenance get results.

be headed off by good plant maintenance. In this connection, the plant includes all real estate, above and below, and equipment.

The steps through which this safety maintenance is achieved are the old standbys—inspection, reporting, repairing and following through. It is to be noted here that all technical and operating departments have a safety function, inasmuch as each is responsible for some degree of inspection and repairing within its own area.

Some larger companies, employing full-time safety inspectors, have set up hard-and-fast rules on clearing up hazardous conditions. The inspector at the end of his visit leaves at the mine or plant a list of the hazards and violations of good practice he has found. Copies of this list are filed in the safety department and with the operations chief. Mine officials are required to take appropriate action to remedy the condition, then report their actions through proper channels to the chief of operations. If such a report does not come up within a specified time, the safety department and chief of operations begin to ask questions. The system insures follow-through on safety-department recommendations.

DEEP MINES—The most important elements in maintaining a deep mine in safe condition are roof support, methane control and dust suppression. Falls of roof, rib and face still are the No. 1 killer, although a striking improvement under bolted roof is now in the records. The most promising remedies are closer supervision, strict compliance with timbering standards and bolting patterns, including as much extra support beyond the standard pattern as necessary, and better trimming of overhanging brows and loose coal. These are the only possible solutions to the problem as long as men are needed at the face.

Efficient ventilation is safe ventilation. Proper methane control demands that sufficient air at reasonable velocity be moved past active faces to dilute and sweep away the gases issuing from the coal. Maintenance of physical plant in the interest of safety demands that bleeders, if they are part of the mining plan, be kept open, that stoppings be sealed against leakage and that airway obstructions be removed. Effective gas detectors also must be considered as safety maintenance tools.

In underground dust suppression the big guns are rock dust and water sprays. The latter may include wetting agents. Recent developments in rock-dusting machinery now permit in-cycle distribution.

Wet rock dusting is the latest application method. Goals are not only a good dusting job but also elimination of the dust problem, which can be particularly acute in dusting in cycle behind a continuous miner. Methods and equipment in two mines are outlined in articles in the following issues: *Coal Age*, February, 1955, p 82; January, 1956, p 62. Now on the market is a slurry-type rock-duster which can be mounted directly on mining machines, and a self-propelled unit.

Whatever the methods, however, the main point is that the rock dust should be evenly distributed, in back headings and returns as well as in more active places. Rock-dust barriers may be included in the overall plan, and the importance of loading out excessive accumulations of coal dust should not be overlooked.

Knocking dust down as it is made by water sprays takes on added importance not only as a means of reducing the explosion hazard but also because of the increased disposition on the part of compensation commissions to grant awards for purported lung damage, even though coal dust still is to be proven as the culprit. For the latest on the question of coal's possible role in lung trouble, see the July, 1956, issue of *Coal Age*, p 56. In any event, prudent management will do its best to keep dust counts below the accepted minimum and supply dust masks when working in high concentrations cannot be avoided.

In all instances, maintenance of a safe plant requires the establishment of fire-fighting systems, including water lines, tested firehoses and chemical extinguishers, where needed. First-aid supplies should be provided in clean, well-lighted rooms.

STRIPPING—In stripping, safety maintenance is primarily a matter of equipment maintenance. A schedule for wire-rope changes should be worked out, since each unexpected rope failure is a potential accident. Haulage trucks must be kept in good condition to head off steering and brake failures particularly. Well-drained smooth-surfaced roads may eliminate dangerous skids, and in dry weather road surfaces should be sprinkled.

Truck spotters must be properly trained to stay out of the way of backing trucks and out of close clearances around dump ramps. They should also be competent in keeping drivers out of trouble.

PREPARATION—In preparation plants, particular check points for safety inspectors are dust accumulations on beams, housekeeping in the oil-storage

MAJOR AIM

COAL TRAINING

SLOGAN CONTEST gets action. Then promote the slogan through wide usage.

area, cleanup precautions before any welding is done, open gearing, exposed wiring, overhead obstructions and so on.

The possibility of using paints of different colors in the plant might be weighed. For example, standard colors for safety include red for fire exit signs and fire equipment; orange on the inside of movable machinery guards and exposed edges of pulleys, gears, rollers and so on; yellow for handrails, top and bottom steps and caution signs; green for first-aid equipment; and black and white for traffic lanes and direction signs.

One final requirement, if all this maintenance is to be meaningful, is that workmen wear proper articles of protective clothing and refrain from wearing loose clothing.

Keeping Interest Alive

Outmoded incentives may diminish enthusiasm for the entire safety effort.

Interesting, well-planned refresher training programs will help keep the safety theme alive.

EMPLOYING INCENTIVES – Ill-advised incentives may not set back the cause of safety but they can be a waste of time for the safety department. A decision to adopt or reject a proposed incentive must be based upon thorough study, with local conditions and personalities weighing heavily in the final judging.

Strange as it may seem, safety bonuses for supervisors have not been an unqualified success in all quarters. The privilege of wearing a white safety hat for supervising a crew through an accident-free month may be more exciting. And even more worthwhile is some scheme where everyone participates in making a good record and shares in the acclaim.

Slogan contests are effective attention getters, if properly conducted. Application blanks may be distributed as payroll inserts. The response will be gratifying if the prize is worthwhile. Then interest and participation in the next contest will be assured if the winning slogan is widely promoted.

Once an incentive has been adopted it must be given a fair chance to succeed. But if it still fails to have the desired effect in creating enthusiasm or reducing accident rates, it must be summarily discarded. Permitting such an incentive to drag on with only half-hearted promotion may be mighty damaging to the entire safety program. Best practice in a situation like this is to have another idea ready to take the place of the incentive you must scrap, although the new idea should be one that has a better-than-even chance of success.

FOLLOW-UP TRAINING – Timely scheduling of refresher training sessions is another way of keeping safety interest at a high level. The accident-prevention training offered by the Bureau of Mines is practically a "must" at all mines because it has captured the interest of the men at mines where it has been given already. Follow-up sessions on this type of training are especially recommended to insure that maximum long-time benefits accrue.

One of the best ways to keep the safety program alive is to look for opportunities to reward individual achievements in safety. The recipients will be happy to have their achievements recognized, and the others will have their interest aroused. Notable individual safety records may be searched out at virtually every mine.

Recent reports from several sectors point up the opportunities to which management should be alert. In one instance, a unit foreman led his crew to the safety of a barricaded position following a disastrous explosion. All were rescued after several hours. In another case, a workman was lowered in a makeshift cage to the bottom of a blast-damaged shaft as the exploratory first step in a recent recovery operation. Subsequent work was based on his exploration. These men were properly honored. Such achievement should not be overlooked. On the other hand, day-by-day attention to safety which results in a commendable record of accident-free performance should be recognized. The cause of safety will be better served.

Maintenance *(Cont'd from p 160)*

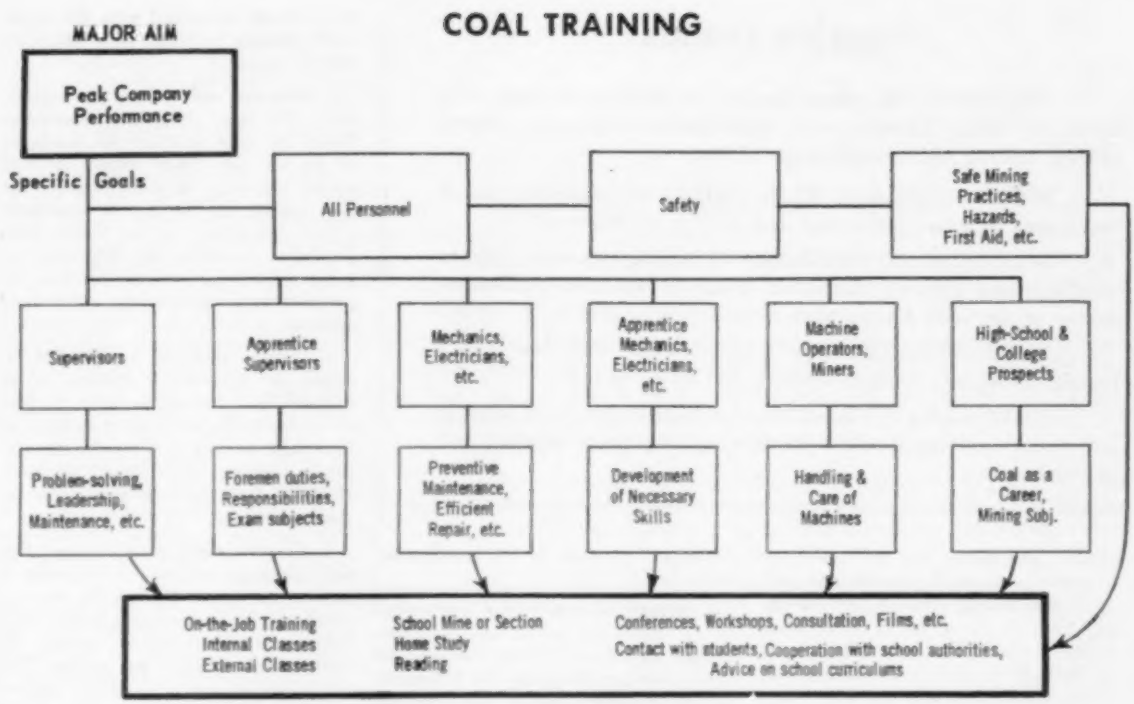
Maintenance Materials

Use hardsurfacing materials whenever possible.

Hardsurfacing products are an example of materials that cut maintenance cost by increasing the life of machines and parts subject to wear, reducing the number of replacements and consequently saving not only in parts and materials but also in labor for replacement.

Examples of the other materials and parts that may be employed to lengthen machine and part life, reduce breakdown time and cut the cost of maintenance include:

1. Stainless and other alloy steel, aluminum and so on for strength, light weight and corrosion resistance in mine cars, truck bodies, stripping dippers, cages and skips, and so on. Light weight, provided there is the requisite strength, in itself reduces the maintenance load, or light weight with high strength permits building up parts without increasing total weight, thus reducing the chances of failures.
2. Stainless steel, manganese-steel and bronze for reducing wear and corrosion in coal screening and other coal-handling processes.
3. Special alloys, bronze, rubber, other corrosion- and abrasion-resisting materials for pumps, valves, fittings and other equipment handling water and water with various solids.
4. Use of lime, by means of automatic feeding equipment, in wet-preparation plants where acid is a problem to reduce corrosion.
5. Cast iron, alloy, asbestos-cement, lined or plastic pipe for mine and other water lines to resist acid.
6. Rubber, tile, sprayed and sand-cement and other corrosion- and abrasion-resisting materials for tanks and storage bins. Some companies have made complete bins of steel-supported glazed tile to resist the effects of abrasion and corrosion.
7. Glass, stainless steel and other wear-resisting materials for chutes, conveyor bottoms.
8. Aluminum, protected-metal and other weather-resistant siding and roofing for preparation plants and other structures.
9. Protective coatings and paint where needed.
10. Silicone, asbestos and other long-lived heat-resistant insulation for electrical equipment.



The Training Guidebook

RAISING THE QUALITY of the mine operating force—both management and men—looms up increasingly as a major need in coal mining. The big and immediate reason is the necessity for getting the maximum returns from the higher investments in both manpower and equipment to preserve the industry's competition position against the continued pressure of substitutes.

A second compelling reason for major emphasis on increasing the skills of the total production force, and for increasing the number of men in certain categories, is meeting the increased demand for coal that will face the industry in the near future—over 600 million tons of bituminous in 1962, for example. Not only is there a need for more skill in mining and management now, but increased output will require more supervisors, engineers, general inside men and preparation men, as well as many more men for equipment maintenance.

One authority, on the basis of an expected 300-million ton jump in output by 1975, estimates personnel needs as follows:

	1955	1975
Supervision, engineering and office	20,000	22,700
General outside labor	6,000	6,500
Preparation	12,000	14,000
Machinery maintenance	26,000	49,000
Haulage	11,000	10,000
General inside men	38,000	41,600
Production men	100,000	38,200
TOTAL	213,000	213,000

The size of the total production force will remain the same although it will be turning out 300 million tons more

Practice Trends

FOREMEN—Emphasis centers on developing new staff from the ranks. Existing staff gets special courses in supervisory, mining and maintenance skills.

MECHANICS AND ELECTRICIANS—Growing needs being met by more classroom and on-the-job training.

MACHINE OPERATORS—Training stresses proper handling and care of machines. A future possibility: School mines or sections for an area or group of mines.

SUPERVISORS AND MANAGERS—Practice favors regular meetings, formal courses and home study.

NEW RECRUITS—Attention focuses on high schools and vocational institutions to develop engineers, miners and supervisors.

of coal. This means that the quality or competence of added personnel, as well as of the sharply reduced face group, will have to be of the highest order. In other words, each man will have to be carefully trained to do his job correctly, quickly, economically and safely then as well as now.

Types of Training

Check over the entire production force to determine what types of training are needed.

Consider the value of training for both specific and general occupational needs.

In evaluating training needs, a company can consider giving its personnel the following types of instruction:

1. **All company personnel**—General safety training. This can help greatly to increase individual safety consciousness and to promote safe mining practices. Certain personnel, furthermore, might receive specialized instruction to suit occupational needs. The underground man, for example, has the greatest need for detailed information on the dangers of inadequate roof support. Similarly, the tippleman needs special coaching on the hazards of preparation plant machinery and equipment.

2. **Mechanics and electricians**—Instruction in preventive maintenance procedures, how to spot equipment troubles quickly, and how to make repairs efficiently.

3. **Machine operators and selected alternates**—Training in how to handle and care for their machines to ensure maximum performance in the production cycle.

4. **Apprentice supervisors**—Instruction in the foreman's duties and responsibilities, and in all mining subjects he must know how to certify for foreman's papers. Trainees should be carefully selected for leadership qualities.

5. **Apprentice mechanics, electricians and shop workers**—Training in the reconditioning and rebuilding of equipment. Recruits can be drawn from company ranks or from outside sources.

6. **Supervisors and managers**—General instruction in how to be better bosses, and special instruction in how to increase their knowledge and skills in certain areas of responsibility. Foremen well trained in spotting equipment troubles and in good preventive maintenance, for example, can contribute much to minimizing downtime.

Success Keys

Organize the training course or program and get competent instructors.

Create a training environment that will encourage employee participation in training programs.

Certain common denominators are basic to the success of any training effort. These are:

1. **Define the objectives** of training and make these publicly known to the maximum number of eligible participants.

2. **Conduct a careful screening** of candidates for new jobs and higher-ranking jobs. Screening is usually based on personal interviews, recommendations from those closely associated with the applicant, aptitude tests, or some combination of these.

3. **Organize and outline** the training. Only the most competent instructors should be used, whether in classrooms or on the job. They should be well versed not only in their subjects but also capable in the art of communication. Instruction can be drawn from a number of sources including company personnel, mining extension services, appropriate state departments, and federal agencies.

4. **Provide adequate, comfortable facilities for classroom instruction,** where included in a training program, as well as authoritative textbook material and illustrative training aids. Equipment, machines and apparatus should be made available for practical application of classroom study.

5. **Create a training environment** that will encourage employee participation in training programs. Salaries for working personnel, for example, should not suffer. Transportation problems should be worked out as much as possible. The company's interest in employee self-improvement should be constantly publicized.

6. **Arrange for periodic follow-up of trainee performance** on the job and make refresher courses or opportunities available to those who want to brush up.

Methods of Training

Use methods best suited to miner training needs.

Give supervisory personnel opportunities to improve their knowledge and skills.

How miners and management personnel are trained depends generally on company training philosophy, the number to be trained, the type of training and who is to be trained. Those methods generally employed, or most desirable, for training miners include the following:

1. **On-the-job mine or shop training.** At least some exposure to this type of training is virtually indispensable for apprentice supervisors, apprentice mechanics and electricians, and machine operators.

2. **Classroom instruction and extension courses.** Where only one, two or a few men are involved, the mining school extension course is frequently the best expedient.

3. **Combined classroom instruction and**

on-the-job training. Some companies find that textbook learning must be accompanied with practical experience for best results.

4. A school mine or section serving a field or a group of company mines. This method is specially good for training new employees, transfers, etc.

For training supervisors and managers, the following techniques are considered good practice:

1. Regular conferences and meetings, including reports from standing or special committees. Free discussion of problems and other matters of mutual interest open the way to increasing the individual supervisor's or manager's knowledge and skill.

2. Formal instruction courses. These may be presented in strictly textbook and/or discussion form, or can be accompanied by laboratory work as, for example, the study of controller panels, etc.

3. Home study and reading. Keeping abreast of current developments in the industry and of good mining practices as, for example, through regular reading of *Coal Age*, is an avenue of learning dependent only on the individual's initiative.

Operating Reports

Testing Personnel—Psychological tests have proved practical in measuring employee ability and personality. Correctly used, they can be a real asset in upgrading personnel selection and placement. *Coal Age*, September, 1957, p 70.

Recruiting Youth—Industry, schools and parents in the Bluefield (W. Va.) area cooperate to whet youthful appetites for careers in engineering and vocational trades. Program activities are directed toward public relations, science fairs, engineer speakers, guidance, and school problems. *Coal Age*, November, 1957, p 54.

Troubleshooting—Classroom and laboratory training aim to develop competent men in electric troubleshooting and maintenance. A basic course covers electrical circuits, contactors and relays, DC motors, and wiring diagrams. Qualified men move to advanced training in hydraulics. *Coal Age*, December, 1957, p 72.

Shop Training—An 18-mo shop training program for new recruits provides a reserve of potential maintenance men. Interest of older workers is increased through a 60-hr course in basic electricity. The payoff: Less downtime. *Coal Age*, January, 1958, p 110.

Foremen Training

Seek to develop new supervisors from the ranks through a program combining classroom instruction and practical experience.

Improve the performance of foremen on the job by giving them regular opportunities to discuss their problems with other foremen and superintendents.

The training of foremen usually breaks down into two main parts: training experienced foremen to do a better job, and training men from the ranks on the foreman's duties and responsibilities.

DEVELOPING NEW FOREMEN — "Imports" of good foremen are becoming scarcer and, furthermore, experience shows that this method is not a reliable means for procuring topnotch career men. Perhaps the best bet for adding to the supply of quality foremen is by upgrading men from the ranks through a combined process of classroom instruction and on-the-job training.

A number of variations of this technique may be employed, especially as these variations deal with the relative amount of time devoted to classroom work and to on-the-job training. One company figures on a 3-mo course which dovetails 600 hr of on-the-job visual education with 75 hr of textbook learning, discussion and home study.

By rotating foremen trainees for 2-wk stretches of on-the-job training in six different mines over a 3-mo period, each man is able to (1) gain first-hand knowledge of a wide variety of seam conditions and mining systems and (2) observe 30 to 40 different foremen on duty. In this way trainees can see for themselves what makes a really good foreman tick. Comparisons are readily made, for example, as to which foremen get the best response from their men and which take the most pains in good housekeeping. Perhaps most important, trainees note:

1. That the mine or section foreman is the key to high productivity.

2. That the foreman's attitude—whether aggressive or lackadaisical—is reflected throughout the ranks of his men.

3. That many mining problems stem from lack of understanding between the foreman and his men.

4. That a good foreman must be able not only to handle men but also to get along with them.

5. That to be successful, a foreman must be a true leader—not only well-informed on the art of mining, but also well-versed in the limits of his authority, and well-practiced in how to be fair and when to be firm to all his men.

On-the-job training should be supplemented with at least 1 hr of classroom instruction per day. It may be necessary to set up two classes to accommodate both day and night shifts. Instruction, given by company or outside experts, or both, should cover all subjects basic to foreman certification. A full curriculum, for example, might include ventilation, gases, approvals and permits, records, general mining practices, explosives, belts and conveyors, electricity, first aid, roof-bolting, general safety, lamp assembly, gas testing and anemometer use. Special instruction on the supervisor's duties, on company standards, and on the importance of human relations in job performance is highly desirable.

Textbook instruction can be based on the state mine foreman's guide (if one is available), or on publications of state mining departments and extension services of mining schools. Such material is usually most effective if adapted and simplified by company instructors.

UPGRADING EXPERIENCED FOREMEN—Foremen on the job can get valuable training through conference discussion of their problems with other foremen and with superintendents. The conference method brings collective experience to bear on current problems and permits valuable exchange of know-how and ideas.

One of the best ways of implementing this technique is through regular meetings at the mines. Foremen meet with their superintendent in his office, or some other suitable place, for 1 or 2 hr. The meetings can be arranged so that each foreman from each shift manages to attend one conference of every two or three.

At these sessions, the freest possible discussion is encouraged—no holds are barred. In this way, many opportunities are provided for practical schooling not

only in operating and labor questions but in mine mathematics, physics and chemistry. Sometimes, foremen are asked to prepare a "laundry list" which promotes discussion on such problems as:

1. How to instill the spirit of cooperation among employees.

2. How to eliminate absenteeism.

3. How to minimize carelessness and "goldbricking."

4. How to recognize desirable characteristics in a satisfactory foreman.

The conference method also finds expression through division- or company-wide meetings. Foremen are taken off the job for 5-day periods and meet in some central geographical spot to participate in an organized conference agenda. Here, the aims are usually broader in scope than at mine meetings. Company activities and policies are discussed and practical help is given in leadership, employee and community relations, efficient conduct of safety, maintenance, production work and product control. An opportunity is provided to meet and get acquainted with top company officials. The program also includes relaxation and entertainment.

For formal instruction to foremen, consider the possibility of giving night classes from September to May. Classes might meet two nights a week from 8 to 10 PM. Subjects covered could include mine engineering and mathematics, public speaking, better reports, techniques of job instruction and conference leadership.

Men from these classes might then be selected for an intensive 2-wk summer course, meeting 6 days a week from 8:30 AM to 4 PM. Successive groups could be selected between June and early September. While they are going to school, foremen should be paid their regular salaries and no charge should be made against vacation time.

Maintenance Training

Investigate the possibilities of in-company training to enlarge and improve the present force.

Consider how supervisor training can aid in reducing maintenance costs.

IMPROVING THE EXISTING FORCE—Modern practice points to in-company training, based on combined classroom instruction and practical experience, as the best way to upgrade the quality of the existing maintenance staff.

One company, for example, sets up a definite course of instruction, on company time, for an initial group of 18 mechanics in three classes of six men each (*Coal Age*, April, 1957, p 76). Each of the three classes meets twice a week, from 8 AM to 11 AM, in a specially equipped classroom near the surface shop. The course is designed to provide a minimum of 48 hr of instruction and practical exercises in electrical theory and trouble-shooting. Before the program is completed, 36 other mechanics have an opportunity to take the training.

Purpose of the training program is to provide means through which the men presently employed as section and shop mechanics can upgrade themselves to handle the problems of modern machine mining more efficiently. In developing this program, management was inspired by these two facts:

1. Good preventive maintenance and the fastest-possible location and clearance of electrical troubles are absolute necessities.

2. No one can criticize the work of a mechanic if he is not equipped with the proper tools and the training he needs to adequately maintain today's mining machines.

With such considerations in mind, operating officials and maintenance men met to discuss ways and means of improving maintenance. The outgrowth of these meetings was a formal instruction program, sponsored by the extension services of one of the leading university mining schools.

Instruction begins with a review of the fundamentals of electricity, including the relationships in Ohm's law, characteristics of series and parallel circuits, and the proper use of meters and instruments. Basic principles of motor operation and the functions of relays and contactors are thoroughly treated, using actual machine components as instructional aids.

The aim of this instruction in fundamentals is to draw together on common ground the six men in each class, who most likely have diverse aptitudes and experience. From this point, the emphasis is on trouble-shooting.

Several concessions are made by the company, and by other mechanics not yet in training. The company agrees to have the men attend the school two days a week for the specified hours and then to complete these shifts on their assigned jobs. This means that, while men are enrolled in the course, they must work steady dayshift during the instruction period. The other mechanics, who enter training later, rotate on the second and third shifts to make this schedule possible.

Benefits of the program indicate that maintenance will be improved through increased job knowledge and job interest among the maintenance men. Reductions in downtime, resulting from faster clearance of outages, are expected to return the investment in training within a reasonable period of time. And a valuable by-product of the training may be the discovery of unrealized leadership talent among the maintenance men.

RECRUITING NEW STAFF—More frequently than not, the announcement of shop training for apprentices brings a deluge of applications, considerably in excess of job quota needs. Thus, one of the biggest jobs in adding new maintenance men is in the selection of trainees.

Initial screening is usually based on personal interviews with operating and maintenance officials. For further screening, aptitude tests may be employed to determine more scientifically a candidate's intelligence, knowledge and fitness for mechanical or electrical work.

In one 18-mo shop training program, trainees are put to work in the central shop, primarily on the rebuilding and reconditioning of equipment. They work with experienced mechanics and electricians, covering all phases of maintenance work, from the dismantling of equipment to final assembly and testing.

Along with practical shop work, lecture and classroom study is provided. This part of the training program is conducted in a central repair shop classroom which is equipped with a lecture and demonstration table, a large blackboard, and an opaque projector and screen. Through the use of these facilities, the basic fundamentals of lubrication, hydraulics, mechanics and electricity are explained and illustrated. A special effort is made to have the lecture material coincide with shop work. To round off the program, representatives of various manufacturing companies give lectures on the construction and care of machines and equipment.

A shop training program of 18-mo duration naturally involves a great deal of instruction time. This may become quite a problem as the need increases for adding more new mechanics, electricians, etc., to the staff. One solution here is to start new trainees on a staggered system so that older trainees can assist newer ones.

SUPERVISOR TRAINING—Substantial savings in production time and maintenance costs can be achieved if foremen have a better appreciation of the care of mining equipment. Such appreciation can be best achieved by showing them how to spot equipment trouble before a major breakdown occurs. A company should expect foremen to take instruction as an opportunity to learn and become better or more valuable employees.

A typical course might include in-

struction in the fundamentals of electricity. Such topics could be covered as Ohm's law, wiring and magnetism, AC and DC principles, DC mine circuits and Lenz's law. With this as a foundation, foreman students could pass to applied maintenance procedures—for example, how to read schematic wiring diagrams, and how to trace and isolate trouble in one part of a circuit and then check items in that section.

The benefits of foremen's maintenance training are not always measurable in dollars and cents. They are reflected in other ways. There is better cooperation between foremen and mechanics. Major breakdowns are prevented since equipment is stopped and repaired before it fails completely. When a failure does take place, there is less downtime because the foreman and mechanic work with the wiring diagram and all effort is directed to fixing the machine rather than to "shooting in the dark." A frequent result is that fewer new parts have to be purchased. Although not easily measurable, benefits add up to more production per shift.

Machine-Operator Training

Consider training in the proper handling and care of machines as a basic factor in achieving maximum mine output.

Explore the possibilities of setting up a school mine or section to provide practical experience in the operation of machinery and equipment.

Miners require a great deal of skill to get top performance from modern coal-mining machines. Thus, adequate training in the handling of continuous miners, shuttle cars, cutting, loading and drilling machines, timbering and roof-bolting machines, etc., becomes a key factor in achieving maximum mine output. Through the proper handling of machines, the operator also plays an important part in preventing abnormal wear and tear which lead to breakdowns and lost production time.

In most cases, machine operators learn their jobs through on-the-job training as helpers to experienced men. Some of the largest machine manufacturers conduct instruction programs on machine operation for customers. Where such training is available, companies should take advantage of it, especially when shifting from conventional to continuous mining machines.

At least one company has found it beneficial to train shuttle-car and cutting-machine operators above ground. A surface course is staked out and chalk-lined to duplicate the turns an operator must make underground. Trainees then practice for 6 or 8 hr periods under the supervision of the mine superintendent or safety director. As a result, machine maneuvering skills are improved and fewer timbers are knocked out.

SCHOOL MINES—A small training mine or section—serving a field or a group of company mines—is an excellent way to provide practical schooling in machinery operation.

This technique would be particularly helpful in training new employees, transfers, etc. It also may help to cut down the cost of training. Coal produced in the training mine can be marketed, like any other coal, through the sponsoring company or association. With an experienced foreman and one or two experienced assistants, the cost of such coal might not be too much higher than coal from a regular working section. And once on their regular assignments their production and safety performance should result in lowest cost.

Safety Training

Aim to give all company personnel a better understanding of their safety responsibilities to themselves and to their co-workers.

Provide thorough training in the proper handling of machinery, equipment and tools, and in actual and potential job hazards.

Better mine engineering will continue as a basic attack in the industry's battle to reduce accidents and fatalities. Equally important, however, is attack on the most stubborn of all obstacles—the foibles of human nature. When every individual realizes more completely his safety responsibilities to himself and his co-workers the stalemate, in all probability, will break. And better individual understanding means primarily one thing: more intensive and extensive safety training and education.

Basic to safety training are the following guideposts:

1. **Safety training** should be given to all personnel, from the manager in the office right down the line to the man at the face.

2. **Unrelenting effort** should be made by all personnel to observe safe mining practices and to comply with safety laws and regulations.

3. **Good housekeeping** should be practiced at all times—carelessness and messiness are the harbingers of accidents.

4. **Thorough training** should be provided in the proper handling of machinery, equipment and tools.

5. **All personnel should be thoroughly indoctrinated** in the actual and potential hazards of their occupations, and properly equipped with safety gear when necessary.

6. **Horseplay and taking chances** should be outlawed.

7. **More emphasis should be placed on getting cooperation** in good safety practice than on inflicting penalties for breach of good practice.

It is difficult to document what individual companies should do to carry out a vigorous campaign of safety training and education since, in each case, methods should be suited to particular needs. But a number of general practices have evolved which have proven their worth, or have received fairly widespread acceptance. These include:

1. **Setting up a committee** to promote the cause of observing safety laws and regulations and to act as liaison between management and labor on grievances.

2. **Posting bulletins, cartoons and other billboard data** at strategic points to arouse safety consciousness on the job.

3. **Instructing foremen to organize weekly meetings** between themselves and their crews for the discussion of current safety problems.

4. **Arranging for USBM instructors** to give their 100% accident prevention training course to all personnel.

5. **Providing instruction** in first-aid and mine-rescue work.

6. **Participating** in safety contests.

7. **Promoting attendance** at Holmes safety chapter meetings.

Pre-employment Training

Expand existing recruitment and publicity programs.

Concentrate on high schools for long-range development of new talent.

The need is urgent for drastic revision of pre-employment training and recruitment programs if the great demand for new young men in the industry is going to be met. Aside from the unusually large needs for maintenance men cited previously, the industry is already faced with an immediate shortage of 250 engineers (*Coal Age*, March, 1957, p 54).

ENGINEERING RECRUITMENT—Essentially, the industry's problems in

selling the coal profession to young men can be solved by improving and expanding existing pre-employment and training programs.

Excellent publicity material has been prepared for all levels of students by the National Coal Association, other coal associations and some companies. Mailings of such material, however, are dwarfed in comparison to educational programs carried on by other industries.

One of the most promising developments on the recruitment scene is increasing management recognition of the importance of interesting high-school students in coal-mining careers. More and more personnel managers are realizing that the high-school student, particularly in coal-mining areas, is the key to long-range fulfillment of personnel needs. However, although a handful of companies are conducting aggressive high school campaigns, only the surface of opportunity has been scratched.

Some 200 scholarships in mining engineering, for example, are offered throughout the country by coal associations and individual companies. But this number is certainly not adequate when compared to the industry's immediate needs for engineers mentioned above. It becomes even less adequate in view of reports that many existing scholarships go unclaimed.

Much could be done to alleviate the scholarship situation by more widespread advertising of scholarships, by sending company and association representatives to recruiting areas to sell the modern coal profession to prospects, and by setting up salary scales and living conditions commensurate with standards in most other professions and industries.

When scholarships are awarded for college study, it is frequently desirable to pin the grantee down to a formal contract. By this contract, the company agrees to pay, say, $1,000 per yr for 4 yr of college education. In return, the grantee agrees to work for the sponsoring company for at least 2 yr after graduation.

Salaries offered sometimes can not be as good as those offered by some other industries. But the differential, where occurring, is made up through the benefits of the 4-yr scholarship. Also, by having the grantee agree to work for at least 2 yr with the company, he is brought to the point where he can take the mine foreman's exam, thus qualifying for higher pay. At least one company has had outstanding success in holding grantees by this system.

MINE RECRUITMENT — Engineers are one industry need, but miners, mechanics, electricians and bosses are equally critical now and in the future. A well-thought-out and well-carried-out program also serves to build the interest which will make recruitment in these categories more rewarding among high-school and junior high-school students.

There are a number of approaches to developing and holding the interest of such students. A typical approach, however, might capture the interest of boys and their parents in the modern coal mining profession through sponsoring science fairs, movies and lectures about coal, and inspection trips to mines. These efforts might be accompanied by offering aid to organize high school mining curricula and to set up vocational guidance committees. It might also prove expedient to subsidize, or otherwise provide, necessary teaching and guidance talent.

High-school mining courses are generally designed for 3 yr and school time is divided between traditional academic subjects and vocational subjects, with careful correlation to insure that boys will become good citizens as well as good miners. A typical course might be made up as follows:

Sophomore Year, Mining Subjects—Geology of coal, mine law, mine gases, ventilation, timbering. **Shop work**—Welding, bench work, lathe, drill, shaper.

Junior Year, Mining Subjects—Tracks and transportation, ventilation, drainage, pumps and pumping, related mathematics. **Shop Work**—Electrical circuits and diagrams, motors and controls, resistances, testing equipment.

Senior Year, Mining Subjects—Explosives and blasting, ventilation, mine law, mapping and drawing, mine chemistry, applied trigonometry. **Shop work**—Hydraulics, general mechanics (clutch, transmission, gears, power), timbering, tracklaying.

All Three Years—Academic Subjects: English, social studies, physical education.

Teachers forming courses like the above are, for the most part, experienced coal mining men. Realizing that teachers with coal mining experience are essential but scarce, coal operators and associations can cooperate to seek out properly qualified men for teaching jobs.

Help in Buying . . .

A COMPLETE CROSS SECTION of the modern equipment, materials and services offered by manufacturers and service organizations is presented in the following pages to round out this 1958 Mining Guidebook issue of *Coal Age*.

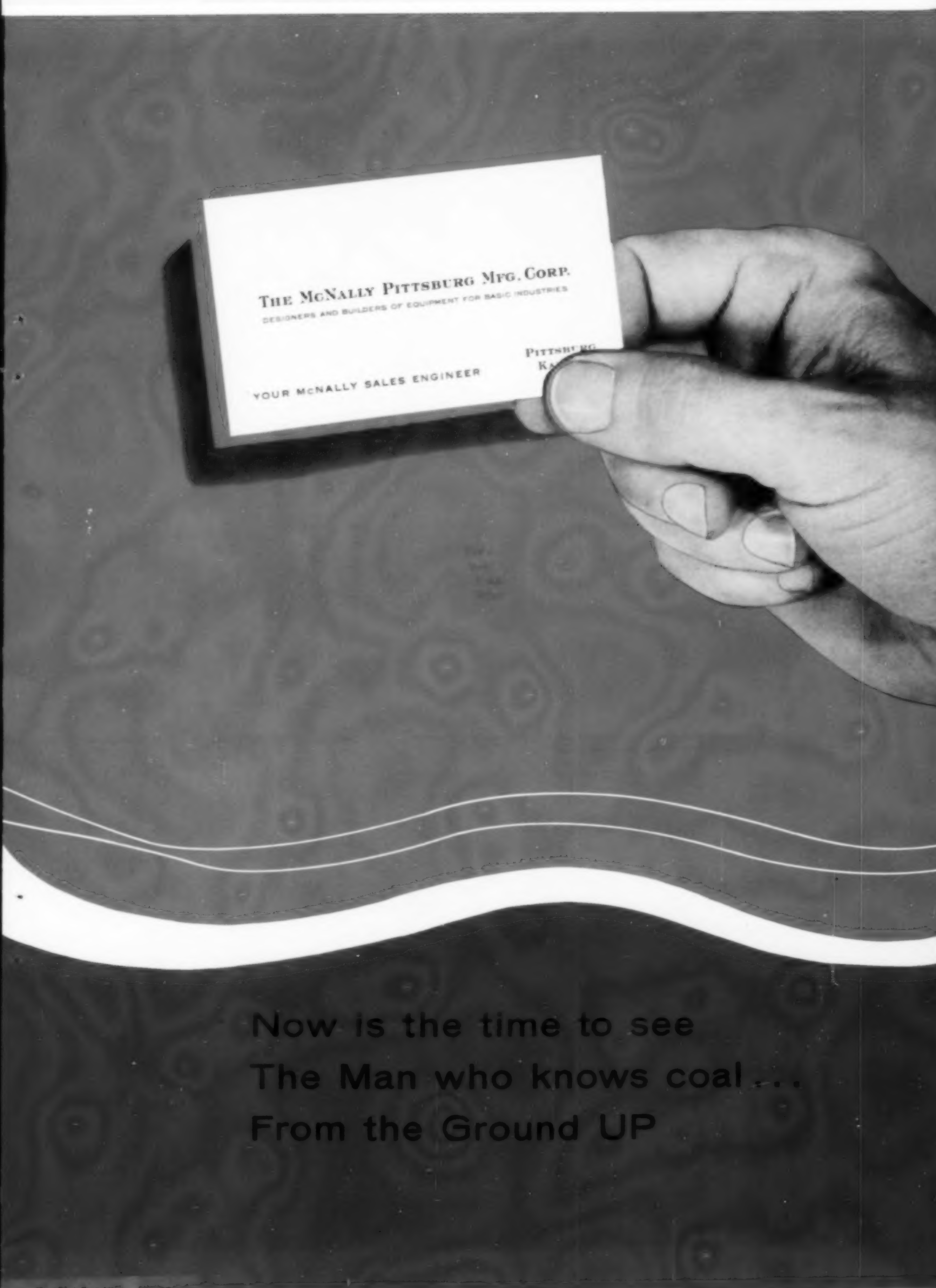
1. If you need equipment, materials and services not previously used . . .

2. If you are interested in additional sources of equipment, materials and services . . .

3. If you are developing a new idea in production, preparation and safety and want to see what's available for carrying it out . . .

Check the Buying Directory beginning on p 185 of this issue. Find the product in the alphabetical list. Under it will appear the names of the key manufacturers, with those advertising in this issue indicated by black-faced type. Trade names also are included in the Buying Directory for convenience in identifying and selecting products.

Consult advertisements in this issue for information on specific products.


THE McNALLY PITTSBURG MFG. CORP.
DESIGNERS AND BUILDERS OF EQUIPMENT FOR BASIC INDUSTRIES
YOUR McNALLY SALES ENGINEER
PITTSBURG
Now is the time to see
The Man who knows coal . . .
From the Ground UP


The Future Belongs to those who Prepare
FOR ALL YOUR PREPARATION NEEDS
—from the GROUND UP—
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COMPLETE PLANTS • ADDITIONS • PARTS
McNally Norton Washers
McNally Mogul Baum Jig
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McNally Rheolaveur Coarse and Fine Coal Launders
McNally Menzies Cone Washer
McNally Brusset Vacuum Jig
McNally Fine Coal Feldspar Jig
McNally Vissac Thermal Dryer
McNally Pulso Dryer
McNally Cascade Dryer
McNally Dryclone
McNally Two-Stage Gearmatic Crusher
McNally Double-Roll, Single-Roll, Stoker Sizing Crushers
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Bearings • Belts • Bins • Booms • Box Car Loaders • Box Car Rescreens • Car Dumps • Car Hauls • Car Retarders • Castings • Chains • Chutes • Coal Breakers • Conveyors • Couplings • Drives • Elevators • Feeders • Gates • Hold-backs • Hoppers • Picking Tables • Pulleys • Pumps • Shafts • Sprockets • Valves
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McNally Pittsburg Manufacturing Corporation—Manufacturing Plants: Pittsburg, Kansas • Wellston, Ohio Engineering and Sales Offices: Pittsburgh • Chicago • Rio de Janeiro • Pittsburg, Kansas • Wellston, Ohio
1975
1970
1960
1958

5½-yd. SHOVEL DELIVERS TOP PRODUCTION IN TIGHT QUARTERS

Capacity alone is not the only measure of a real mining shovel . . . ability to move overburden *anywhere* at lowest cost can be a deciding factor. The Manitowoc 5½-yd. Model 4500 shovel is engineered from the crawlers up as a true mining machine . . . combining long reach, big capacity and reserve power with the all-important mobility to get in and work in close quarters.

A single diesel power package eliminates several electric motors, miles of wiring, control boards, delicate electrical connections, expensive power installations in remote areas and a restrictive trailing cable . . . the 4500 travels *anywhere*. Maintenance is simple . . . easily handled by your regular mechanics.

For consistently greater mining output the Manitowoc 4500 has simple, powerful main machinery having only 15 gears . . . simplified air controls . . . smooth, torque converter power. A 60 foot hi-lift shovel boom is available when more reach is needed . . . dragline booms in various lengths meet any job requirements.

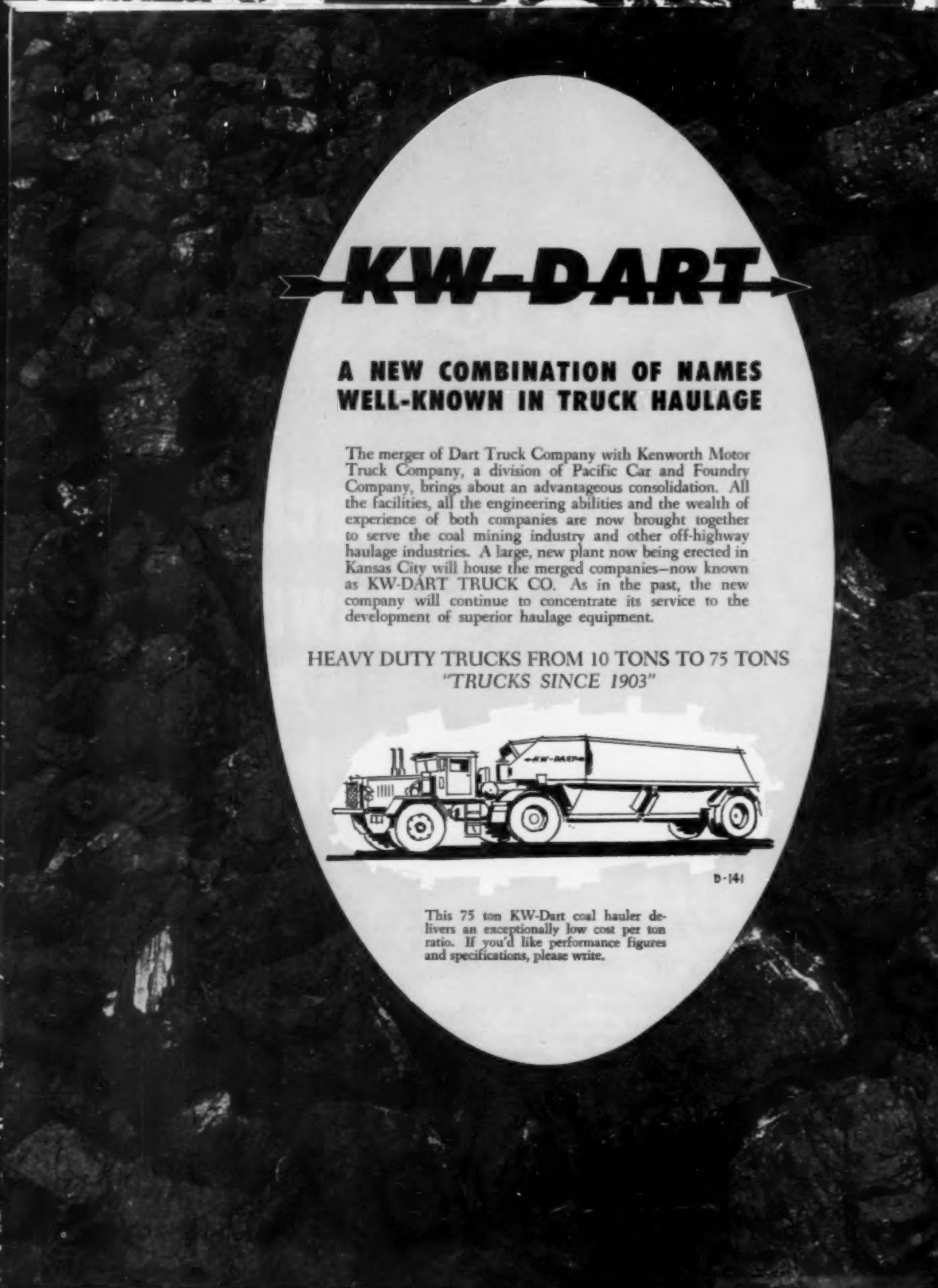
Your Manitowoc distributor has many more profitable facts on the Model 4500 . . . get in touch with him now!

MANITOWOC ENGINEERING CORP. Manitowoc, Wis.

SHOVELS 1-5½-YD.

Manitowoc

CRANES 20-100 TON


KW-DART
A NEW COMBINATION OF NAMES WELL-KNOWN IN TRUCK HAULAGE
The merger of Dart Truck Company with Kenworth Motor Truck Company, a division of Pacific Car and Foundry Company, brings about an advantageous consolidation. All the facilities, all the engineering abilities and the wealth of experience of both companies are now brought together to serve the coal mining industry and other off-highway haulage industries. A large, new plant now being erected in Kansas City will house the merged companies—now known as KW-DART TRUCK CO. As in the past, the new company will continue to concentrate its service to the development of superior haulage equipment.
HEAVY DUTY TRUCKS FROM 10 TONS TO 75 TONS
"TRUCKS SINCE 1903"
D-141
This 75 ton KW-Dart coal hauler delivers an exceptionally low cost per ton ratio. If you'd like performance figures and specifications, please write.

The 1958 Coal Age Mining Guidebook . . .

Buying Directory

Equipment . . . Materials . . . Services

Directory of Manufacturers, p 294; Advertising Index, p 316. **Black-faced type** indicates a product-information advertisement in this issue.

EQUIPMENT, MATERIALS AND SERVICES FOR COAL MINING, together with the names of those who furnish them, are shown in Part 1 of this Buying Directory, starting on this page.

All products, materials and services, with their suppliers in each instance, are listed alphabetically under the key words. For example, look for "Bearings, Roller," rather than "Roller Bearings." If a product does not appear under one possible classification —for example, "Cable, Welding"—look for the alternative listing—in this instance, "Welding Cable."

BLACK-FACED TYPE indicates a manufacturer or supplier providing more detailed data on available equipment, materials and services through product-information advertisements in this issue. (see p 316 for Advertising Index).

THE ADDRESSES of the manufacturers, suppliers and service organizations appearing in the Buying Directory are listed under the company names in the Directory of Manufacturers beginning on p 294 of this issue. For added convenience in obtaining equipment, services and materials offered by advertisers in this issue, their sales offices and representatives are shown by states in the Advertising Index beginning on p 301. A special Searchlight advertising section is indexed beginning on p 310.

ACETYLENE GENERATORS

Air Reduction Sales Co., Div. of Air Reduction Co., Inc.
Marathon Coal Bit Co. Inc.—"AIRCO"
The Sight Feed Generator Co.—"SIGHT FEED"

ACTUATORS, CYLINDER, LINE VALVES

Ledeen, Inc.

ADDITIVES, FUEL-OIL

Warren Refining & Chemical Co.—"PVR"

ADDITIVES, LUBRICANT

Dow Corning Corp.
E. I. du Pont de Nemours & Co., Inc.
Shell Oil Co.
Stewart-Warner Corp., Alemite Div.
Warren Refining & Chemical Co.—"PVR"

ADHESIVES

B. F. Goodrich Industrial Products Co.—"PLASTILOCK," "VULCALOCK," "DUO-LOCK"

AERATORS, BIN

Bin-Dicator Co.—"BIN-FLO"
Convair

AERIAL PHOTOS

Aero Service Corp.
American Air Surveys, Inc.

AERIAL PLATFORMS

Pitman Manufacturing Co.—"GIRAFFE"

AERIAL SURVEYING, MAPPING

Aerial Surveys, Inc.
American Air Surveys, Inc.
Jack Ammann Photogrammetric Engineers, Inc.
Fairchild Aerial Surveys, Inc.

AERIAL TRAMWAYS

Interstate Equipment Corp.

AFTERCOOLERS, AIR

Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Worthington Corp.

AGITATOR CONDITIONERS

The Daniels Co., Contractors, Inc.
Eimco Corp.
Western Machinery Co.—"WEMCO"

AIR CLEANERS, COAL

Link Belt Co., Dept. CAMGL-58
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.—"SUPER-AIRFLOW"
Stephens-Adamson Mfg. Co.—"AIR-SAND"

AIR COMPRESSORS

Schroeder Brothers Corp.

AIR COMPRESSORS, CENTRIFUGAL

American Blower, Div. of American Standard

AIR COMPRESSORS, PORTABLE, MINE

Acme Machinery Co.
Cardox Corp.—"AIRDOX"
Emglo Products Corp.—"EMGLO"
Gardner-Denver Co.
M. Glosser & Sons Inc.
Imperial-Cantrell Mfg. Co. —"CANTRELL"
Joy Mfg. Co.—"MINEAIR"
Morse Bros. Machinery Co.

AIR COMPRESSORS, PORTABLE, SURFACE

Cardox Corp.—"AIRDOX"
Chicago Pneumatic Tool Co.
Davey Compressor Co.
Gardner-Denver Co.
Imperial - Cantrell Mfg. Co. —"CANTRELL"
Ingersoll-Rand Co.—"GYRO-FLO"
Joy Mfg. Co.—"AIRVANE"
Le Roi Div., Westinghouse Air Brake Co.
Morse Bros. Machinery Co.
Schramm, Inc.—"PNEUMA-POWER," "UNISTAGE"
Worthington Corp.

AIR COMPRESSORS, SELF-PROPELLED

Acme Machinery Co.
Davey Compressor Co.
Goodman Mfg. Co.
Imperial-Cantrell Mfg. Co.—"CANTRELL"
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Morse Bros. Machinery Co.
Schramm Inc.—"PNEUMA-TRACTOR"

AIR COMPRESSORS, STATIONARY

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"ROFLO"
Cardox Corp.—"AIRDOX"
Chicago Pneumatic Tool Co.
Davey Compressor Co.
Emglo Products Corp.— "EMGLO"
Gardner-Denver Co.
M. Glosser & Sons Inc.
Imperial-Cantrell Mfg. Co.—"CANTRELL"
Ingersoll-Rand Co.
Joy Mfg. Co.—"INDUSTRIAL AIR"
Le Roi Div., Westinghouse Air Brake Co.
Morse Bros. Machinery Co.
Nash Engineering Co.
Ore Reclamation Co.
Penn Machine Co.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Schramm, Inc.—"UNISTAGE"
Worthington Corp.

AIR CONDITIONERS

American Blower, Div. of American Standard.

AIR-LINE FILTERS

Snap-on Tool Corp.

AIR-LINE OILERS

Acme Machinery Co.
The Branford Co. — "BRANFORD"
Chicago Pneumatic Tool Co.
Davey Compressor Co.
Gardner-Denver Co.
Ingersoll-Rand Co.—"OIL-IR"
Joy Mfg. Co.
Schroeder Bros. Corp.
Stewart-Warner Corp., Alemite Div.
Thor Power Tool Co.

AIR RECEIVERS

Acme Machinery Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
L. O. Koven & Bro., Inc.
Pennsylvania Pump & Compressor Co.
Worthington Corp.

AIR SEPARATORS, MECHANICAL

Gruendler Crusher & Pulverizer Co.
Hardinge Co., Inc.
Majac, Inc., Sub. of Blackstone Corp.
New Jersey Meter Co.—"DRI-AIR"
Universal Road Machinery Co. —"GAYCO"
Western Precipitation Corp. — "MULTICLONE"
Williams Patent Crusher & Pulv. Co.

AIR SUSPENSIONS

Clark Equipment Co.

ALARMS, BEARING-TEMPERATURE

The Bristol Co.—"BRISTOL'S"
Foxboro Co.
West Instrument Corp.

ALARMS, TRUCK BACKUP

E. D. Bullard Co.

ALIDADES, PLANETABLE

Kern Instruments, Inc.

ALLOYS, ACID, CORROSION, WEAR-RESISTING

A. M. Byers Co.

ALLOYS, NICKEL

International Nickel Co., Inc.

ALTIMETERS

American Paulin System—"MICRO," "TERRA"

AMMETERS

National Mine Service Co.

AMMETERS, CLAMP-ON

General Electric Co., Apparatus Sales Div.
Martindale Electric Co.

AMMETERS, INDICATING

General Electric Co., Apparatus Sales Div.
Westinghouse Electric Corp.

AMMETERS, RECORDING

The Bristol Co.—"BRISTOL'S"
General Electric Co., Apparatus Sales Div.
Westinghouse Electric Corp.

AMMONIUM NITRATE, INDUSTRIAL

Allied Chemical & Dye Corp., Nitrogen Div.
Austin Powder Co.
Collier Carbon & Chemical Corp.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
Fisher Scientific Co.
Hercules Powder Co.
National Powder Co.
Spencer Chemical Co.

ANALYZERS, COAL-SULPHUR

Fisher Scientific Co.

ANALYZERS, GAS

Hays Corp.

ANALYZERS, SULPHUR, RAPID

Laboratory Equipment Co. — "LECO"

ANALYZERS, VOLATILIZATION

Laboratory Equipment Co.— "LECO"

ANEMOMETERS

Fisher Scientific Co.
Mine Safety Appliances Co.
National Mine Service Co.

ANTIFOAM AGENTS

Hodag Chemical Corp.

ANTI-FOG GOGGLE CLEANER

American Optical Co., Safety Products Div.—"SUPER-CLEAR"
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.—"FOGPRUF"
United States Safety Service Co. —"SAF-I-LENS"

ANTIFREEZE

American Minechem Co.
American Oil Co.
E. I. du Pont de Nemours & Co., Inc. — "ZERONE," ® "ZEREX" ®

ARCHES, SUSPENDED FURNACE

Bigelow-Liptak Corp.

ARMATURE GROWLERS, TESTERS

Martindale Electric Co.
Snap-on Tools Corp.

ARMATURE REWINDING

Flood City Brass & Electric Co.
Guyan Machy. Co.
National Mine Service Co.
Pennsylvania Electric Coil Corp.
Scranton Electric Construction Co.
West Virginia Armature Co.
Westhinghouse Electric Corp.

ARMATURE TOOLS

Martindale Electric Co.

ASHING EQUIPMENT, RAPID

Laboratory Equipment Co. — "LECO"

ATHLETE'S-FOOT PREVENTIVE

Onox, Inc.—"ONOX"

AUGER EXTENSIONS

The Leetonia Tool Co.
Mobile Drilling, Inc.

AUGER SOCKETS

The Leetonia Tool Co.
Mobile Drilling, Inc.

AUGERS, BREAST

Marathon Coal Bit Co. Inc.— "SALEM"
The Salem Tool Co.—"SALEM"

AUGERS, COAL-RECOVERY

Cardox Corp.
Compton, Inc.
Link-Belt Co., Dept. CAMGL—58
Marathon Coal Bit Co. Inc.— "SALEM"
Metallurgical Products Div., General Electric Co.—"CARBOLOY"
The Salem Tool Co.—"McCARTHY"
Taylor-Wharton Co., Div. Harsco Corp.

AUGERS, COAL-SHOTHOLE

Central Mine Equipment Co.
Dooley Bros.
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.— "McLAUGHLIN"
McLaughlin Mfg. Co., Inc.
Metallurgical Products Dept. General Electric — "CARBOLOY"
Mobile Drilling, Inc.
The Salem Tool Co.—"HERCULES"
Schroeder Bros. Corp.

AUGERS, EARTH

Acker Drill Co. Inc.—"ALL-PURPOSE (AP) DIGGER"
Central Mine Equipment Co.
The Four Wheel Drive Auto Co.
H & L Tooth Co.
Herb J. Hawthorne, Inc.— "BLUE DEMON"
The Leetonia Tool Co.
Link-Belt Co. Dept. CAMGL—58
Marathon Coal Bit Co. Inc.— "McLAUGHLIN"
McLaughlin Mfg. Co., Inc.
Mobile Drilling, Inc.
Pennsylvania Drilling Co.
The Salem Tool Co.—"BLACK DIAMOND"
The Wood Shovel & Tool Co.

AUGERS, ROCK-BLASTHOLE

Central Mine Equipment Co.
Herb J. Hawthorne, Inc. — "BLUE DEMON"
Marathon Coal Bit Co. Inc.— "McLAUGHLIN"
Metallurgical Products Dept., General Electric Co.—"CARBOLOY"
Mobile Drilling, Inc.
The Salem Tool Co.—"McCARTHY"

AUGERS, ROOF DRILL

Kennametal Inc.

AXES, MINERS'

American Logging Tool Corp., Sub. of Broderick & Bascom Rope Co.

AXLES, CARS, MINE EQUIPMENT

American Car & Foundry Div., ACF Industries, Inc.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Flood City Brass & Electric Co.
Gibralter Equipment & Mfg. Co.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
Sanford Day Iron Works, Inc.
Sterling Steel Casting Co.
Watt Car & Wheel Co.

AXLES, DRIVE, STEERING, AUTOMOTIVE SPECIAL

Clark Equip. Co., Automotive Div.

AXLES, FRONT, DRIVING

Transmission and Axle Div., Rockwell Standard Corp.

AXLES, FRONT, NON-DRIVING

Transmission and Axle Div., Rockwell Standard Corp.

AXLES, REAR, SINGLE, TANDEM

Transmission and Axle Div., Rockwell Standard Corp.

AXLES, PLANETARY, STEERING AND RIGID

Transmission and Axle Div., Rockwell Standard Corp.

AXLES, TRAILER, TUBULAR AND I SECTION

Transmission and Axle Div., Rockwell Standard Corp.

BACK RIPPERS, BULLDOZER

Preco Incorporated—"PRECO"

BACKSTOPS

American Pulley Co.
Barber-Greene Co.
Bonded Scale & Machine Co.
Chain Belt Co.—"REX"
Continental Gin Co., Ind. Div.
Hewitt-Robins Incorporated—"JONES"
Kremser & Sons, Inc., Frank A
Link-Belt Co., Dept. CAMGL-58
Marland One-way Clutch Co.
McNally-Pittsburg Mfg. Corp.
Ore Reclamation Co.
Webster Mfg., Inc.

BAGS, AIR-FILTER

Bemis Bro. Bag Co.
C. R. Daniels Co.
The Daniels Co., Contractors, Inc.
The Ducon Co., Inc.
John Flocker & Co.
Koppers Co., Inc., Metal Products Div.
National Filter Media Corp.
Western Precipitation Corp.— "DUALAIRE"
Wheelabrator Corp.

BAGS, COAL WASHING FILTER

National Filter Media Corp.

BAGS, DISK-FILTER

Eimco Corp.

BAGS, DISK-FILTER STAINLESS WIRE

Peterson Filters & Engineering Co.

BAGS, DUST COLLECTOR

National Filter Media Corp.

BAGS, MULTIWALL

Bemis Bro. Bag Co.—"RIPP-NIPP," "STRENGTH-END"
Chase Bag Co.

BAGS, POLYETHYLENE

Bemis Bro. Bag Co. — "FLIP-CLOSE"
Chase Bag Co.
Eimco Corp.
Peterson Filters & Engineering Co.—"SARAN"
Tamping Bag Co. Div., Pickard Industries, Inc.

BAGS, POWDER

American Brattice Coth Corp.
Bemis Bro. Bag Co.—"BANG BAGS"
C. R. Daniels Co.
Fulton Bag & Cotton Mills
Mine Safety Appliances Co.
National Powder Co.
Tamping Bag Co. Div., Pickard Industries, Inc.

BAGS, TAMPING

American Cyanamid Co., Explosives and Mining Chemicals Dept.
Atlas Powder Co.
Bemis Bro. Bag Co.
Chase Bag Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
King Powder Co., Inc.
National Mine Service Co.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.
Tamping Bag Co., Div., Pickard Industries, Inc.

BAGS, WATERPROOF

Bemis Bro. Bag Co.
Chase Bag Co.

BALLS, STEEL

New Departure Div., General Motors Corp.
SKF Industries, Inc.

BARGE-HANDLING EQUIPMENT

Dravo Corp.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Roberts & Schaefer Co., Sub. Thompson Starrett Co., Inc.
Sanford Day Iron Works, Inc.
Stephens-Adamson Mfg. Co.

BARGES

Bethlehem Steel Co.
Dravo Corp.
Marietta Mfg. Co.
Wiley Manufacturing Co.

BAROGRAPHS

American Paulin System—"MICRO"

BAROMETERS

American Paulin System—"MICRO," "TERRA"
The Bristol Co.—"BRISTOL'S"
Fisher Scientific Co.

BARS, APPLICATOR

Stulz - Sickles Co. — "MANGANAL"

BARS, COLD-FINISHED

H. K. Porter Co., Connors Steel Div.

BARS, GRIZZLEY

Colorado Fuel & Iron Corp. "C F & I"

BARS, MERCHANT

H. K. Porter Co., Connors Steel Div.

BARS, SLATE

Duquesne Mine Supply Co.
The Leetonia Tool Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
The Salem Tool Co.—"SALEM"

BASKETS, CLOTHES

C. R. Daniels Co.
The Moore Co.

BASKETS, WOVEN-WIRE

Cleveland Wire Cloth & Mfg. Co.

BATTERIES, DRY

United States Rubber Co.

BATTERIES, SHOT-FIRING

National Mine Service Co.

BATTERIES, STORAGE

C & D Batteries, Inc.—"SLY-VER - CLAD," "PLASTI-CELL," "PLASTICAL"
Compton, Inc.
Thomas A. Edison Industries, McGraw-Edison Co., Storage Battery Div.—"EDISON"
Exide Industrial Div., Electric Storage Battery Co. — "EXIDE-IRONCLAD," "EXIDE POWERCLAD"
Goodyear Tire & Rubber Co.
Gould-National Batteries, Inc.
Kersey Mfg. Co., Inc.
National Mine Service Co.
Yardney Electric Corp. — "YARDNEY SILVERCEL," "YARDNEY SILCAD"

BATTERY-CHARGING EQUIPMENT

C & D Batteries, Inc.—"AUTO-REG"
Cornell-Dubilier Electric Corp. —"POWERCON"
Exide Industrial Div., Electric Storage Battery Co.
General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
General Scientific Equipment Co.—"GS"
Gould-National Batteries, Inc.
Hobart Bros. Co.
Ironton Engine Co.—"IRONTON"
Joy Mfg. Co.
Kersey Mfg. Co., Inc.
The Lincoln Electric Co.—"PRECISION-CHARGE"
Mine Safety Appliances Co.
Syntron Co.
Westinghouse Electric Corp.

BEARING MATERIAL, PHENOLIC RESIN

American Brake Shoe Co., American Brakeblok Div.

BEARING METAL

American Brake Shoe Co., National Bearing Div.
Ampco Metal, Inc.—"AMPCO"
Bearings, Inc.
Crucible Steel Co. of America
Imperial-Cantrell Mfg. Co. — "IC"
Johnson Bronze Co.
Joseph T. Ryerson & Son, Inc.
Webster Mfg., Inc.
West Virginia Armature Co.

BEARING OILERS

Herold Mfg. Co.

BEARINGS, BALL

Ahlberg Bearing Co.—"AHLBERG"
Bantam Bearings Div., Torrington Co.
Bearing Service Co.
Bearings, Inc.
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"SC," "SLP," "SCM"
Ensign Electric & Mfg. Co.
The Fafnir Bearing Co.
The Federal Bearings Co. Inc.
Flood City Brass & Electric Co.
Guyan Machy. Co.
Link-Belt Co.—Dept. CAMGL-58—"JPS"
Marlin — Rockwell Corp. — "M-R-C"
McNally-Pittsburg Mfg. Corp.
Mosebach Electric & Supply Co.
National Mine Service Co.
New Departure Div., General Motors Corp.
Norma-Hoffman Bearings Corp.
SKF Industries, Inc.
Ore Reclamation Co.
Stephens-Adamson Mfg. Co.—"SEALMASTER"
Torrington Co.
Transall, Inc.
T. B. Woods Sons Co.
West Virginia Armature Co.

BEARINGS, BRONZE

American Brake Shoe Co., National Bearing Div.
Link-Belt Co., Dept. CAMGL-58

BEARINGS, CARBON

Helwig Co.
Ohio Carbon Co.—"KARAK"
Pure Carbon Co., Inc.

BEARINGS, HANGER

Link-Belt Co., Dept. CAMGL-58
Vickers, Inc.—"TUSLA (Two speed)"

BEARINGS, JOURNAL

American Brake Shoe Co., National Bearing Div.
American Brake Shoe Co., Railroad Products Div.

BEARINGS, NEEDLE

Bantam Bearings Div., Torrington Co.
Bearing Service Co.
Bearings, Inc.
Torrington Co.

BEARINGS, ROLLER

Bantam Bearings Div., Torrington Co.
Bearing Service Co.
Bearings, Inc.
Chain Belt Co.—"SHAFER"
Chain Belt Co., Shafer Bearing Div.
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"SPHER-ALIGN"
Enterprise Wheel & Car Corp.
Gibraltar Equipment & Mfg. Co.
Guyan Machy. Co.
Hyatt Bearings Div., General Motors Corp.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "MILL BEARING," "SPHERICAL"
Marlin-Rockwell Corp.—"M-R-C"
McNally-Pittsburg Mfg. Corp.
Mosebach Electric & Supply Co.
National Mine Service Co.
Norma - Hoffmann Bearing Corp.
Ore Reclamation Co.
Rollway Bearing Co., Inc.
SKF Industries, Inc.
Torrington Co.
West Virginia Armature Co.

BEARINGS, ROLLER, SPLIT

Bearing Service Co.
Bearings, Inc.
Link-Belt Co., Dept CAMGL-58
Transall, Inc.

BEARINGS, SLEEVE

Allison Div., General Motors Corp.
American Brake Shoe Co., National Bearing Div.
American Crucible Products Co.
Ampco Metal, Inc.—"AMPCO"
Bearings, Inc.
Dodge Mfg. Corp.—"SLEEVOIL"
Flood City Brass & Electric Co.
Imperial-Cantrell Mfg. Co.—"IC"
Johnson Bronze Co.
Link-Belt Co., Dept CAMGL-58—"LINK-BELT"
Mosebach Electric & Supply Co.
Bertrand P. Tracy Co.
Transall, Inc.
Webster Mfg., Inc.
West Virginia Armature Co.

BEARINGS, SLEEVE, CONVERSION

Bearings, Inc.
Imperial-Cantrell Mfg. Co.—"IC"
Johnson Bronze Co.
West Virginia Armature Co.

BEARINGS, SLEEVE, SELF-LUBRICATING

Keystone Carbon Co.

BEARINGS, TAPERED ROLLER

SKF Industries, Inc. — "TYSON"
The Timken Roller Bearing Co.
Tyson Bearing Co., Div. of SKF Industries, Inc.

BEARINGS, THRUST

Bantam Bearings Div., Torrington Co.
Bearings, Inc.
Bearing Service Co.
Gibraltar Equipment & Mfg. Co.
The Federal Bearings Co. Inc.
Johnson Bronze Co.
Link-Belt Co., Dept. CAMGL-58
Marlin-Rockwell Corp.—"M-R-C"
New Departure Div., General Motors Corp.
Norma-Hoffmann Bearing Corp.
Ore Reclamation Co.
Rollway Bearing Co., Inc.
SKF Industries, Inc.
Torrington Co.

BELT-LOADING STATIONS, AUTOMATIC

Link-Belt Co., Dept. CAMGL-58
Nolan Co.

BELTS, CHAIN

Link-Belt Co., Dept. CAMGL-58

BELTS, FLAT TRANSMISSION

Boston Woven Hose & Rubber Co., Div. of American Biltrite Rubber Co.
Carlyle Rubber Co., Inc.
Cincinnati Rubber Mfg. Co., Div. of Thor Power Tool Co.
C. R. Daniels Co.
Goodall Rubber Co.
Goodrich Co., B. F., Industrial Products Div. — "HIGH FLEX"
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Manheim Mfg. & Belting Co.
Ore Reclamation Co.
Paltech Co.
Quaker Rubber Div., H. K. Porter Co. Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div. — "CONDOR"
Republic Rubber Div., Lee Rubber & Tire Co.—"CHALLENGER"
Scandinavia Belting Co.—"SCANDINAVIA," "SCANDILEX"
Talcott, Inc.
Thermoid Co.
Transall, Inc.
United States Rubber Co.

BELTS, MINERS LEATHER

National Mine Service Co.

BELTS, POWER TRANSMISSION

Extremultus, Inc.

BELTS, V

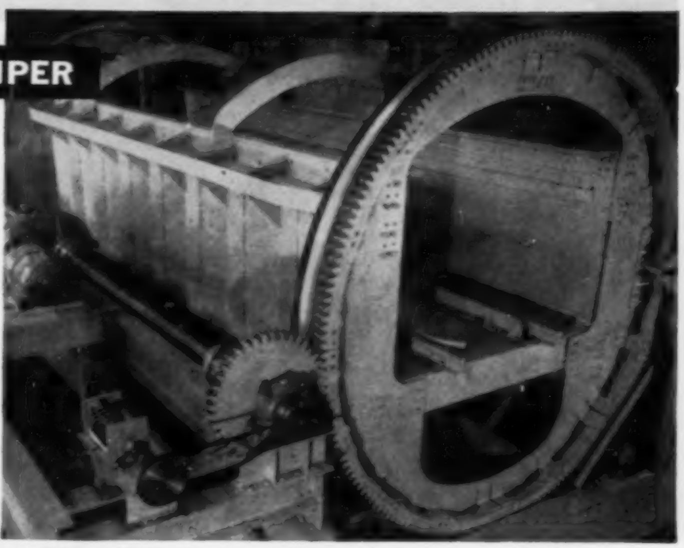
Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"TEX-ROPE"
American Pulley Co.—"WEDG-BELT"
Boston Woven Hose & Rubber Co., Div. of American Biltrite Rubber Co.
Browning Mfg. Co.
Carlyle Rubber Co., Inc.
J. D. Christian Engineers
Dodge Mfg. Corp.—"SEALED-LIFE"
Flood City Brass & Electric Co.
The Gates Rubber Co. Sales Div., Inc.
Goodall Rubber Co.
Goodrich Co., B. F. Industrial Products Div.—"GROMMET"
Goodyear Tire & Rubber Co.
Guyan Machy. Co.
Industrial Rubber Products Co. —(Pa.)
Link-Belt Co., Dept. CAMGL-58
Mosebach Electric & Supply Co.
National Mine Service Co.
Ore Reclamation Co.
Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.—"CONDOR," "SUPER-POWER"
Republic Rubber Div., Lee Rubber & Tire Co.—"REPUBLIC"
Thermoid Co.
Transall, Inc.
United States Rubber Co.
T. B. Woods Sons Co.
Worthington Corp.

BELTS, V-LINK

Guyan Machy. Co.

THE NOLAN PROFIT-PAIR
to meet modern mining requirements

NOLAN ROTARY CAR DUMPER



The newest, safest design in high-speed dumping through full 360° arc. Fully automatic with selective manual control. The result of 50 years of Nolan experience and progress in mine car dumping and control equipment.

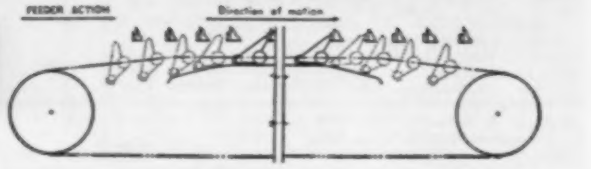
FEATURES:

—Designed for Today's High Capacity Mine Car
—Gear Driven through Flame Hardened Gears
—Complete with Base Frame, Dump Sheets, and Liner Plates
—Anti-friction Bearings Throughout
—Wide Faced Dump Rings of Special Alloy Steel
—Equipped with Nolan Patented Cushioned Rail Aligning Stop

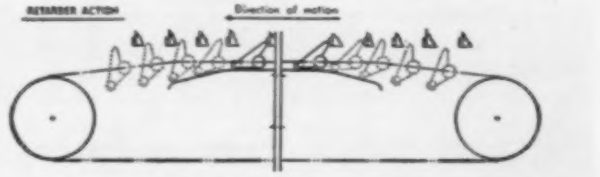
NOLAN CUSHION-ACTION TRIP FEEDER-RETARDER

The NOLAN Cushion-Action Feeder-Retarder makes possible the easy, accurate control of mine cars . . . and eliminates the wracking, jolting, inflexible action so common in ordinary chain control types.

Through the ingenious design of dogs, rails and chain, the feeding and retarding of mine cars becomes an easy, gentle, positive action. The diagrams at the right picture the Cushion-Action of this new NOLAN advancement, available only through NOLAN. Consult us for adaptation of the new NOLAN Cushion-Action principle to your particular feeder-retarder problems.



Feeder dog is pivoted on pin carrying outboard rollers of chain. Tail of dog has roller. Third track under center of chain governs position of dog with relation to vertical. Note difference in angle between chain track and dog track. As dogs progress along their track, they gradually assume an upright position and engage their respective pusher pads. At other end of frame, dogs *gradually* drop away from their pads. No straining, jolting or jarring as dogs engage and disengage.



Retarder dogs operate on same principle as feeder dogs and are situated adjacent to them. Gradually assume upright position and engage their respective retarder pads, holding back cars firmly and steadily. At end of chain, retarder dogs *gradually* drop away from their pads, without snapping or wracking of cars.

NOLAN AGENTS:

Huntington Supply & Equipment Co.
Huntington Nat'l Bank Building
Huntington, West Virginia

John Lloyd & Sons
33 Bennett Building
Wilkes-Barre, Pennsylvania

E. C. Horne Machinery Company
1726 Champa Street
Denver 2, Colorado

George C. Hutchinson, Jr.
1304 Keenan Building
Pittsburgh, Pennsylvania

Frank C. Memmott
P. O. Box 154
Castle Gate, Utah

Amos A. Culp
429 South 24th Street
Birmingham 5, Alabama

John North Associates
P.O. Box 105
Harbert, Michigan
(Chicago District)

THE NOLAN COMPANY
BOWERSTON, OHIO

National Mine Service Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
T. B. Woods Sons Co.

BELTS, V-LINK ADJUSTABLE

Manheim Mfg. & Belting Co. —"VEELOS V"

BENDERS, PIPE, CONDUIT

Blackhawk Mfg. Co.
National Electric Products Co.

BENDERS, PIPE, BAR STOCK, ANGLE IRON, O. D. TUBING, RIGID CONDUIT

Hossfeld Mfg. Co. — "HOSSFELD UNIVERSAL"

BINDERS, LOAD

Crosby Laughlin Div. American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
American Logging Tool Corp., Sub. of Broderick & Bascom Rope Co.
Coffing Hoist Div., Duff-Norton Co.

BIN DEVICES

Fairmont Machinery Co.—"BCR EASY-FLO"

BIN GATES

Blaw-Knox Co.
C. S. Card Iron Works
Chain Belt Co.—"REX"
Gruendler Crusher & Pulverizer Co.
Helmick Foundry-Machine Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
E. F. Marsh Engrg. Co. — "MARCO"
McNally-Pittsburg Mfg. Corp.
Meckum Engr. Co.
Ore Reclamation Co.
Pioneer Engineering, Div. of Poor & Co.
Roberts & Schaefer Co., Sub Thompson-Starrett Co., Inc.
Smith Engineering Works—"TELSMITH"
Stephens-Adamson Mfg. Co. — "MOORE," "DUPLEX," "TRIPLEX"
Thomas Engineering & Construction Co.
Webster Mfg., Inc.
Wilmot Engineering Co.

BIN-LEVEL INDICATORS

Bin-Dicator Co. — "BINDICATOR," "BANTAM BINDICATOR," "ROTO BINDICATOR"
Convair—"BIN-VUE"
Hewitt-Robins Incorporated — "ROBINTRONIC"
Industrial Physics & Electronics Co.
Jeffrey Mfg. Co.
Stephens-Adamson Mfg. Co. — "TELLEVEL"

BIN VIBRATORS

The Branford Co. — "BRANFORD"
Cleveland Vibrator Co.
Eriez Mfg. Co.
W. S. Tyler Co.—"TY-SPEED"

BINS, COAL STORAGE, BLENDING, SLATE

Barber-Greene Co.
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58
Neff & Fry Co.

BINS, PARTS-STORAGE

The Frick-Gallagher Mfg. Co. —"ROTABINS"
Kanawaha Mfg. Co.
McNally-Pittsburg Mfg. Corp.

BINS & HOPPERS, COAL-STORAGE, BLENDING

Bethlehem Steel Co.
The Daniels Co., Contractors, Inc.
Diamond Iron Works, Div., Goodman Mfg. Co.
Enterprise Wheel & Car Corp.
Fairmont Machinery Co.
Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
L. O. Koven & Bro., Inc.
Link-Belt Co., Dept. CAMGL-58
Meckum Engr. Co.
Marietta Concrete Corp.
E. F. Marsh Engrg. Co. — "MARCO"
McNally-Pittsburg Mfg. Corp.
Ore Reclamation Co.
Pioneer Engineering, Div. of Poor & Co.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Thomas Engineering & Construction Co.
Universal Engineering Co.

BITS, CUTTER

Herold Mfg. Co.

BITS, CUTTER, ALLOY-STEEL

The Bowdil Co.
Cardox Corp.
Central Mine Equipment Co.
Cincinnati Mine Machinery Co. — "CINCINNATI," "DUPLEX-TIPPED"
Crucible Steel Co. of America—"REX,"
Cutter Bit Service Co.—"CUT-RITE"
H & L Tooth Co.
Marathon Coal Bit Co. Inc. — "CRUCIBLE"
Penn Machine Co.
The Salem Tool Co.—"HERCULES"

BITS, CUTTER, CARBON-STEEL

Austin Powder Co.
Crucible Steel Co. of America
Cutter Bit Service Co.—"CUT-RITE"
Howells Mining Drill Co.
Joy Mfg. Co.
The Leetonia Tool Co.
Marathon Coal Bit Co. Inc. — "UNION FORGE"
The Salem Tool Co.—"BLACK DIAMOND"

BITS, CUTTER, CARBIDE-INSERT-TIPPED

Allegheny Ludlum Steel Corp.
Austin Powder Co.
The Bowdil Co.
Cincinnati Mine Machinery Co. —"CINIDE"
Cutter Bit Service Co.—"CUT-RITE"
Firth Sterling, Inc.—"FIRTHITE"
Guyan Machy. Co.
Hoffman Bros. Drilling Co.
Kennametal, Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc. — "CARBOLOY," "BORDER CITY"
Metal Carbides Corp.
Metallurgical Products Dept. General Electric Co.—"CARBOLOY"
Mobile Drilling, Inc.
National Mine Service Co.
Newcomer Products, Inc.
Penn Machine Co.
The Salem Tool Co.— "SALEM"
Vascoloy-Ramet Corp.

BITS, CUTTER, HARD-SURFACED, PLATED, TIPPED

The Bowdil Co.
Cardo Corp.
Central Mine Equipment Co.
Cutter Bit Service Co.—"CUT-RITE"
Mobile Drilling, Inc.
Penn Machine Co.
Frank Prox Company, Inc.
The Salem Tool Co.— "SALEM"

BITS, CUTTER, HARD-SURFACED, TIPPED

Cincinnati Mine Machinery Co. —"CINCINNATI," "DUPLEX-TIPPED"

BITS, CUTTER, THROWAWAY

The Bowdil Co.
Cardox Corp.
Central Mine Equipment Co.
Cincinnati Mine Machinery Co. —"DUPLEX," "STANEX"
Hoffman Bros. Drilling Co.
Marathon Coal Bit Co. Inc.— "MARATHON," "COAL MASTER"
Mobile Drilling, Inc.
National Mine Service Co.
Penn Machine Co.
Frank Prox Company, Inc.— "TOOL STEEL"
The Salem Tool Co.— "SALEM"

BITS, DOWN-THE-HOLE

Stardrill-Keystone Co.

BITS, DRILL, COAL

Austin Powder Co.
Cardox Corp.
Central Mine Equipment Co.
Compton, Inc.
Dooley Brothers
Gibraltar Equipment & Mfg. Co.
Herb J. Hawthorne, Inc.— "BLUE DEMON"
Howells Mining Drill Co.
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.— "McLAUGHLIN," "COAL-MASTER"
McLaughlin Mfg. Co., Inc.
Mobile Drilling, Inc.
National Mine Service Co.
Newcomer Products, Inc.
Paris Mfg. Co.
The Salem Tool Co.— "SALEM"
Schroeder Brothers Corp.

BITS, DRILL, COAL, CARBIDE-TIPPED

Allegheny Ludlum Steel Corp.
Austin Powder Co.
Brunner & Lay, Inc.
Firth Sterling, Inc.—"FIRTHITE"
Herb J. Hawthorne, Inc.— "BLUE DEMON"
Hoffman Bros. Drilling Co.
Howells Mining Drill Co.
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.— "CARBOLOY," "BORDER CITY"
McLaughlin Mfg. Co., Inc.
Metal Carbides Corp.
Metallurgical Products Dept., General Electric Co.—"CARBOLOY"
Mobile Drilling, Inc.
Newcomer Products, Inc.
Paris Mfg. Co.
Frank Prox Company, Inc.
The Salem Tool Co.— "SALEM"
Schroeder Brothers Corp.
Vascoloy-Ramet Corp.

BITS, DRILL, CHURN

Spang & Co.

BITS, DRILL, CORE

George E. Failing Co., Sub. of Westinghouse Air Brake Co.
Hoffman Bros. Drilling Co.
Joy Mfg. Co.
Kennametal Inc., Mining Tool Div.
Mobile Drilling, Inc.
Newcomer Products, Inc.
Pennsylvania Drilling Co.
Sprague & Henwood
Varel Mfg. Co., Inc.

BITS, DRILL, CORE, DIAMOND, CARBIDE, SHOT, SAWTOOTH

Acker Drill Co. Inc.

BITS, DRILL, DIAMOND

Diamond Tool Research Co., Inc.—"DTR"
George E. Failing Co., Sub. of Westinghouse Air Brake Co.
Hoffman Bros. Drilling Co.
Joy Mfg. Co.—"TRUCO"
Metal Carbides Corp.
Mobile Drilling, Inc.
Pennsylvania Drilling Co., Masonry Drill Div.
J. K. Smit & Sons, Inc. — "HARD HED"
Sprague & Henwood
Varel Mfg. Co., Inc.

BITS, DRILL, DIAMOND, RESETTING SERVICE

Diamond Tool Research Co., Inc.—"DTR"
Sprague & Henwood

BITS, DRILL, MASONRY

Pennsylvania Drilling Co., Masonry Drill Div.

BITS, DRILL, MOLEFOOT, STRIPPING

Cardox Corp.
Central Mine Equipment Co.
Marathon Coal Bit Co. Inc.— "McLAUGHLIN," "CARBOLOY"
Mobile Drilling, Inc.
Paris Mfg. Co.
The Salem Tool Co.— "SALEM"

BITS, DRILL, PERCUSSION

Acme Machinery Co.
Brunner & Lay, Inc.
Bucyrus-Erie Co.
Gardner-Denver Company
Guyan Machy. Co.—"THROWAWAY"
Ingersoll-Rand Co.
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Mobile Drilling, Inc.
Schroeder Brothers Corp.

BITS, DRILL, PERCUSSION, CARBIDE-INSERT, ALL STEEL MULTI-USE

The Timken Roller Bearing Co.

BITS, DRILL, PERCUSSION, CARBIDE-TIPPED

Brunner & Lay, Inc.—"ROK-BITS"
Joy Mfg. Co.
Ingersoll-Rand Co.—"CARSET"
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.— "TIMKEN"
Metal Carbides Corp.
Newcomer Products, Inc.
B. J. Nykerk Corp.—"HAUSHERR"
Vascoloy-Ramet Corp.

BITS, DRILL ROOF-CARBIDE-TIPPED

Allegheny Ludlum Steel Corp.
Austin Powder Co.
Brunner & Lay, Inc.—"INTRA-SET"
Firth Sterling, Inc.—"FIRTHITE"
Guyan Machy. Co.—"FIRTHITE"
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc— "CARBOLOY," "BORDER CITY"

Metal Carbides Corp.
Metallurgical Products Dept., General Electric Co.—"CARBOLOY"
Mobile Drilling, Inc.
Newcomer Products, Inc.
Frank Prox Company, Inc.
Vascoloy-Ramet Corp.

BITS, DRILL, ROTARY, DRY, STRIPPING

Austin Powder Co.
Cardox Corp.
Central Mine Equipment Co.
Davey Compressor Co.
George E. Failing Co., Sub. of Westinghouse Air Brake Co.
Herb J. Hawthorne, Inc.—"BLUE DEMON"
Hoffman Bros. Drilling Co.
Hughes Tool Co.
Kennametal Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.—"McLAUGHLIN," "CARBOLOY"
Mobile Drilling, Inc.
H. C. Smith Oil Tool Co.
Stardrill-Keystone Co.
Varel Mfg. Co., Inc.—"AIR-BLAST"

BITS, DRILL, ROTARY, WET, STRIPPING

Cardox Corp.
Herb J. Hawthorne, Inc.—"BLUE DEMON"
Hoffman Bros. Drilling Co.
Hughes Tool Co.
Marathon Coal Bit Co. Inc.—"CARBOLOY," "C. P. ROTARY"
H. C. Smith Oil Tool Co.
Varel Mfg. Co., Inc.

BITS, DRILL, ROTARY, WET, CARBIDE-TIPPED, STRIPPING

Allegheny Ludlum Steel Corp.
Firth Sterling, Inc.—"FIRTHITE"
Herb J. Hawthorne, Inc.—"BLUE DEMON"
Marathon Coal Bit Co. Inc.—"CARBOLOY"
Metal Carbides Corp.
Metallurgical Products Dept., General Electric Co.—"CARBOLOY"
Mobile Drilling, Inc.
Varel Mfg. Co., Inc.
Vascoloy-Ramet Corp.

BITS, FINGER, CARBIDE-TIPPED

Firth Sterling Inc.—"FIRTHITE"
Vascoloy-Ramet Corp.

BITS, ROCK, CONE-TYPE-ROLLER

Herb J. Hawthorne, Inc.

BITS, STRIP, FINGER, CARBIDE-TIPPED

Firth Sterling Inc.—"FIRTHITE"

BIT BOXES

Duquesne Mine Supply Co.

BIT HOLDERS, MULTIPLE, INDIVIDUAL

Frank Prox Co., Inc.

BIT-RESETTING SERVICE, DIAMOND

Hoffman Bros. Drilling Co.
Joy Mfg. Co.
J. K. Smit & Sons, Inc.
Sprague & Henwood

BIT SHARPENERS, COAL BITS

Fairview Bit Co.
Joy Mfg. Co.

BIT SHARPENERS, ROCK BITS

Bucyrus-Erie Co.
Fairview Bit Co.
Hoffman Bros. Drilling Co.
Ingersoll-Rand Co.
Joy Mfg. Co.

BIT-SHARPENING SERVICE

Brunner & Lay, Inc.
Fairview Bit Co.
Hoffman Bros. Drilling Co.
Howells Mining Drill Co.
Marathon Coal Bit Co. Inc.

BLADE CONTROLS, AUTOMATIC-GRADER

Preco Incorporated—"PRECO"

BLASTING AGENTS

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"CYAMITE," "ACCOMITE"
Atlas Powder Co. — "AMOCOL," "AMOCORE," "CHEMEX," "ATLAS GRANULES," "ATLAS PRILLS"
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.—"NITRAMEX," "NITRAMITE," "NITRAMON"
Hercules Powder Co.
King Powder Co., Inc.

BLASTING CAPS

American Cyanamid Co., Explosives and Mining Chemicals Dept.
Atlas Powder Co.—"MANASITE"
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
Hercules Powder Co.
King Powder Co., Inc.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div. — "BIG INCH"

BLASTING CAPS, ELECTRIC

Atlas Powder Co.—"MANASITE," "ROCKMASTER"

BLASTING MACHINES

American Cyanamid Co., Explosives and Mining Chemicals Dept.
Atlas Powder Co.—"SHOTMASTER"
Hercules Powder Co.

BLASTING METERS

Hercules Powder Co.—"VAO"

BLASTING WIRE

American Cyanamid Co., Explosives and Mining Chemicals Dept.
Atlas Powder Co.

BLASTING WIRE, CORD

Cornish Wire Co., Inc.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
King Powder Co., Inc.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.
The Salem Tool Co.—"SALEM"

BLENDERS

Stedman Foundry & Machine Co., Inc.

BLENDING AND PROPORTIONING SYSTEMS

ABCs ® Scale Div., McDowell Co., Inc.

BLOCK SIGNALS, AUTOMATIC

American Mine Door Co.
Nachod & U. S. Signal Co.

BLOCKS, CRANE-HOOK

Upson-Walton Co.—"MAX-LIFT"

BLOCKS, MANILA-ROPE

Upson-Walton Co.

BLOCKS, WHEEL

The Aldon Co.

BLOCKS, WIRE-ROPE

Crosby Laughlin Div., American Hoist & Derrick Co. — "CROSBY"
Guyan Machy. Co.
Joy Mfg. Co.
Sauerman Bros., Inc.—"DURO-LITE"
Upson-Walton Co.

BLOWERS, CENTRIFUGAL

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Blower, Div. of American-Standard
Buffalo Forge Co.
E. K. Campbell Co.—"EKCCO"
Chelsea Fan and Blower Co., Inc.
Clarage Fan Co.
Coppus Engineering Corp.
Hauck Mfg. Co.
Ilg Electric Ventilating Co.—"ILG"
Ingersoll-Rand Co.
Jeffrey Mfg. Co.
Roots-Connersville Blower, Div. Dresser Industries, Inc.
Westinghouse Electric Corp.
Westinghouse Electric Corp., B. F. Sturtevant Div.

BLOWERS, CIRCULATING, DRAFT

American Air Filter Co., Inc.
Buffalo Forge Co.
E. K. Campbell Co.—"EKCCO"
Clarage Fan Co.
F. R. Hannon & Sons—"HANCO"
Joy Mfg. Co.—"AXIVANE"
Sanford Day Iron Works, Inc.
Westinghouse Electric Corp., B. F. Sturtevant Div.

BLOWERS, CLEANING, MAINTENANCE

American Mine Door Co.—"ACE"
Holub Industries, Inc.
Joy Mfg. Co.—"AXIVANE"
Martindale Electric Co.
Westinghouse Electric Corp., B F. Sturtevant Div.

BLOWERS, JIG

Roots-Connersville Blower, Div. Dresser Industries, Inc.

BLOWERS, PORTABLE, MINE

American Blower, Div. of American Standard
Buffalo Forge Co.
Chelsea Fan and Blower Co., Inc.
Coppus Engineering Corp.—"VANO," "VENTAIR"
Herold Mfg. Co.
Jeffrey Mfg. Co. — "AERODYNE"
Joy Mfg. Co.—"AXIVANE"
Mine Safety Appliances Co.
Morse Bros. Machinery Co.
Roots-Connersville Blower, Div. Dresser Industries, Inc.
Westinghouse Electric Corp., B. F. Sturtevant Div.

BLOWERS, TUBING

B. J. Nykerk Corp. — "HAUSHERR"

BLOWERS, VENTILATING, GASOLINE, PORTABLE

Homelite, Div. Textron Inc.—"HOMELITE"

BOILERS, HEATING

Dallas Engineers Inc., Coal-O-Matic Div. — "ANTHRA-FLO," "COAL-O-MATIC"

BOILERS, HEATING, HOT-WATER

Axeman-Anderson Co.
L. O. Koven & Bro., Inc.

BOLT-HOLE CLEANERS

Mine Safety Appliances Co.—"M-S-A"

BOLTS

Bethlehem Steel Co.
Duquesne Mine Supply Co.—"REDIPT"
Guyan Machy. Co.
Republic Steel—"REPUBLIC"
Sheffield Div., Armco Steel Corp.

BOLTS, TRACK—See Rail Bolts

BONDS, RAIL—See Rail Bonds

BOOSTERS, AIR/OIL, SINGLE STROKE

Ledeen, Inc.

BORING MILLS

Farrel-Birmingham Co., Inc.

BOX-CAR LOADERS

Eimco Corp.
Link-Belt Co., Dept. CAMGL-58—"JET SLINGERS"
Lippmann Engrg. Works
Morse Bros. Machinery Co.
Stephens-Adamson Mfg. Co.—"SWIVELOADER," "SINDEN"

BOX-CAR UNLOADERS

Link Belt Co., Dept. CAMGL-58—"LINK BELT," "KAR-FLO"
Stephens-Adamson Mfg. Co.

BOXES, DETONATOR

J. V. Hammond Co.
King Powder Co., Inc.
Mine Safety Appliances Co.

BOXES, POWDER

E. I. du Pont de Nemours & Co. Inc., Explosives Div.
J. V. Hammond Co.
King Powder Co., Inc.
Mine Safety Appliances Co.

BOXES, POWDER, SAFETY WOOD

E. I. du Pont de Nemours & Co., Inc., Explosives Div.
J. V. Hammond Co.
King Powder Co., Inc.
Mine Safety Appliances Co.

BRAKE BLOCKS

Irwin Foundry & Mine Car Co.
Johns-Manville—"J-M"
Raybestos Manhattan, Inc. Manhattan Rubber Div.
Thermoid Co.
Wagner Electric Corp.
S. K. Wellman Co. — "VELVETOUCH FERAMIC" (¾ in only)

BRAKE BLOCKS, WOOD

Enterprise Wheel and Car Corp.
J. V. Hammond Co.
Irwin Foundry & Mine Car Co.

BRAKE FLUID, HYDRAULIC

Socony Mobil Oil Co. Inc.
United States Rubber Co.

BRAKE FRICTION, LINING

American Brake Shoe Co., American Brakeblok Div.
Goodyear Tire & Rubber Co.
Guyan Machy. Co. — "J-M," "VELVETOUCH"
Johns-Manville—"J-M"
Mining Machine Parts Inc.
Raybestos Manhattan, Inc. Manhattan Rubber Div.
Thermoid Co.
Wagner Electric Corp.
S. K. Wellman Co. — "VELVETOUCH"

BRAKE MOTORS

Reliance Electric and Engrg. Co.

BRAKE SHOES, METALLIC

American Brake Shoe Co., Railroad Products Div.
Duquesne Mine Supply Co.
Flood City Brass & Electric Co.
(Continued on p 196)

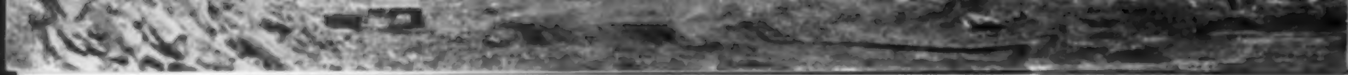

FAIRMONT—Helpful Partner to the Coal Industry!
This is the service mark FAIRMONT that has been a
beacon to the coal industry for
over sixty years Fairmont whose
engineering skill has led to coal cleaning
plants of better than 99%
separating efficiency and which helps the operator
get the upgraded product to market
and delivered at top dollar value.
Call or write us today.
FAIRMONT MACHINERY COMPANY
FAIRMONT, WEST VIRGINIA
DESIGNERS AND CONSTRUCTORS OF COMPLETE COAL PREPARATION PLANTS USING BOTH WET AND DRY CLEANING, CENTRIFUGAL AND THERMAL DRYING.

Coal Chief scoops and dumps 100 tons a minute!

Four Boom Support Strands, each $3\frac{5}{8}$" dia., support the huge boom which towers 160 feet above the ground. These Tiger Brand cables are designed for long service life.

USS American Tiger Brand Hoist Rope. Two of these $2\frac{5}{8}$" dia. shovel hoist ropes supply the guts to lift the heaviest loads.

6,000 tons of overburden per hour can be stripped by this new 70-cubic-yard Marion shovel built for Simco Peabody Company and Columbus & Southern Power.



Helmick Foundry-Machine Co.
Irwin Foundry & Mine Car Co.
National Mine Service Co.

BRAKES, LININGS
S. K. Wellman Co.—"VELVE-TOUCH"

BRAKES, LOCOMOTIVE
Goodyear Tire & Rubber Co.
Helmick Foundry-Machine Co.
National Mine Service Co.

BRAKES, LOWERING-CONVEYOR
Vulcan Iron Works

BRAKES, MAGNETIC
Clark Controller Co.
Cutler-Hammer, Inc.
Dings Magnetic Separator Co.
General Electric Co., Apparatus Sales Div.
Westinghouse Electric Corp.

BRAKES, MAGNETIC, EDDY-CURRENT
Dynamatic Div., Eaton Mfg. Co.

BRAKES, MAGNETIC, FRICTION
Dynamatic Div., Eaton Manufacturing Co. — "DYNA-TORQ"

BRAKES, MINE-CAR
American Car & Foundry Div. ACF Industries, Inc.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Gibralter Equipment & Mfg. Co.
Goodyear Tire & Rubber Co.
Helmick Foundry-Machine Co.
Irwin Foundry & Mine Car Co.

BRAKES, MOTOR
The Master Electric Co.

BRAKES, TRUCK, AIR
Eaton Mfg. Co., Axle Div.
The Four Wheel Drive Auto Co.
Rockwell-Standard Corp., Brake Div.
Wagner Electric Corp.

BRAKES, TRUCK, HYDRAULIC
The Four Wheel Drive Auto Co.
Rockwell-Standard Corp., Brake Div.
Wagner Electric Corp.

BRAKES, TRUCK, HYDRO-DYNAMIC AUXILIARY
The Parkersburg Rig & Reel Co.—"HYDROTARDER"

BRAKES, TRUCK, MECHANICAL
Rockwell-Standard Corp., Brake Div.

BRATTICE CLOTH
American Brattice Cloth Corp.
C. R. Daniels Co.
John Flocker & Co.—"MOR-OPA"
Goodrich Co., B. F., Industrial Products Div. — "KORO-SEAL"
National Mine Service Co.

BRATTICE CLOTH, PLASTIC
John Flocker & Co.

BRATTICE, INFLATABLE
American Brattice Cloth Corp.

BREAKERS, COAL REVOLVING
American Steel Foundries—"WEARPACT"
Heyl & Patterson, Inc.—"BRADFORD"
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Pennsylvania Crusher Div., Bath Iron Works Corp.

BREAKERS, IMPACT
Pioneer Engineering, Div. of Poor & Co.

BREAKERS, PICK-TYPE, PREPARATION
McNally-Pittsburg Mfg. Corp.

BREAKERS, PAVING
Gardner-Denver Company
Ingersoll-Rand Co.
Joy Mfg. Co.
Le Roi Div. Westinghouse Air Brake Co.
Marathon Coal Bit Co. Inc.—"IRON CITY"
Syntron Co.
Thor Power Tool Co.

BREAKERS, PAVING, ELECTRIC
Homelite, Div. Textron Inc.—"HOMELITE (BOSCH)"

BREATHING APPARATUS
Mine Safety Appliances Co.—"CHEMOX," "McCAA TWO-HOUR"

BRIDGES, COAL HANDLING
Heyl & Patterson, Inc.
Dravo Corp.
Link-Belt Co., Dept. CAMGL-58

BRUSH HOLDERS
Helwig Co.
Link-Belt Co., Dept. CAMGL-58
National Mine Service Co.
West Virginia Armature Co.
Westinghouse Electric Corp.

BRUSHES, CARBON
Flood City Brass & Electric Co.
Guyan Machy. Co.
Helwig Co.
Keystone Carbon Co.
National Carbon Co., Div. of Union Carbide Corp.
National Mine Service Co.
Ohio Carbon Co.
Pure Carbon Co., Inc.
Stackpole Carbon Co.
Standard Carbon Co.
Superior Carbon Products, Inc.
West Virginia Armature Co.
Westinghouse Electric Corp.

BRUSHES, METAL GRAPHITE
Superior Carbon Products, Inc.

BUCKET CHAINS, DRAGLINE
Kensington Steel, Div. of Poor & Co.
Link-Belt Co., Dept. CAMGL-58

BUCKET TEETH, BASES, INSERTS
American Brake Shoe Co., Amsco Div.—"AMSCO"
American Steel Foundries—"WEARPACT"
Blaw-Knox Co.
Bucyrus-Erie Co.
Electric Steel Foundry Co.
H & L Tooth Co.
Kensington Steel, Div. of Poor & Co.
Page Engineering Co.
Taylor-Wharton Co., Div. Harsco Corp.

BUCKET-TEETH REPOINTERS
American Brake Shoe Co., Amsco Div.—"AMSCO"
Kensington Steel, Div. of Poor & Co.
Stulz-Sickles Co. — "WING-DING"

BUCKETS, AERIAL TRAMWAY
Irwin Foundry & Mine Car Co.
Watt Car & Wheel Co.

BUCKETS, CLAMSHELL
Blaw-Knox Co.
Electric Steel Foundry Co.
George Haiss Mfg. Co., Div. Pettibone Mulliken Corp.
Orton Crane & Shovel Co.
Salem-Brosius, Inc.
Schield Bantam Co.

BUCKETS, CONVEYOR, ELEVATOR
American Brake Shoe Co., Amsco Div.—"AMSCO"
Bonded Scale & Machine Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Enterprise Wheel and Car Corp.
Gruendler Crusher & Pulverizer Co.
Hendrick Mfg. Co.
Hewitt-Robins Incorporated
Heyl & Patterson, Inc.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kensington Steel, Div. of Poor & Co.
Kremser & Sons, Inc., Frank A.
Laubenstein Mfg. Co.
Link-Belt Co., Dept. CAMGL-58 "LINK-BELT"
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburg Mfg. Corp.
Meckum Engr. Co.
Ore Reclamation Co.
K. Prins & Associates
Remaly Mfg. Co. Inc.
W. J. Savage Co.
Smith Engineering Works
Sprout, Waldron & Co., Inc.
Stephens-Adamson Mfg. Co.
Transall, Inc.
Universal Engineering Co.
Universal Road Machinery Co. "RELIANCE"
Watt Car & Wheel Co.
Webster Mfg., Inc.
Wilmot Engineering Co.

BUCKETS, DRAGLINE
Bucyrus-Erie Co.
Electric Steel Foundry Co.
Hendrix Mfg. Co.
Page Engineering Co.—"AUTO-MATIC"
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
Taylor-Wharton Co., Div. Harsco Corp.

BUCKETS, DRAGLINE-CHAINS & FITTINGS
Hendrix Mfg. Co.

BUCKETS, DRAGLINE—ARCHES, CHAINS, FITTINGS
Bucyrus-Erie Co.
Electric Steel Foundry Co.
Page Engineering Co.

BUCKETS, DRILL-DUST
Mine Safety Appliances Co.—"DRIL-DUST"

BUCKETS, DUMP
Salem-Brosius, Inc.

BUCKETS, ELEVATOR
Link-Belt Co., Dept. CAMGL-58 —"LINK-BELT"

BUCKLES
General Logistics — "WEB-LOCK"

BUGDUSTERS, AUTOMATIC
Goodman Mfg. Co.
Joy Mfg. Co.

BUILDINGS, PRE-ENGINEERED
The Parkersburg Rig & Reel Co.

BUILDINGS, PREFAB
Armco Drainage & Metal Prod., Inc.
Arrowhead Constructors and Engineers Inc.
Republic Steel—"TRUSCON"
Steel-Bilt Construction Co.
Steelcraft Mfg. Co.
Thomas Engineering & Construction Co.

BULLDOZER CORNER ADAPTERS
H & L Tooth Co.

BULLDOZER CORNER BITS
American Brake Shoe Co., Amsco Div.
Kensington Steel, Div. of Poor & Co.

BULLDOZER & GRADER BLADES
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Brake Shoe Co., Amsco Div.
American Steel Foundries — "WEARPACT"
Caterpillar Tractor Co.
Colorado Fuel & Iron Corp.—"C F & I"
Electric Steel Foundry Co.
Gar Wood Industries, Inc.
The Frank G. Hough Co.
International Harvester Co., Construction Equipment Div.
LeTourneau-Westinghouse Co.
The Oliver Corp.—"OLIVER"

BULLDOZER RIPPER TEETH
American Brake Shoe Co., Amsco Div.

BULLDOZERS
Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Austin-Western, Construction Equipment Div., Baldwin-Lima-Hamilton Corp.
J. I. Case Co.—"CASE-TERRA-TRAC"
Caterpillar Tractor Co.
Eimco Corp.
International Harvester Co., Construction Equipment Div.
LeTourneau-Westinghouse Co.—"TOURNA-TRACTOR"

BULLETIN-BOARD SERVICE
Elliott Service Co., Inc.

BUMPERS, LOCOMOTIVE
Kanawha Mfg. Co.
Leman Machine Co.
West Virginia Armature Co.

BUMPERS, MINE-CAR
American Car & Foundry Div., ACF Industries, Inc.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
Sanford Day Iron Works, Inc.
Watt Car & Wheel Co.
West Virginia Armature Co.

BUMPERS, RUBBER
Continental Rubber Works
Hewitt-Robins Incorporated

BUS BAR, ALUMINUM
Aluminum Co. of America

BUS BAR, ELECTRICAL, ALUMINUM
Reynolds Metals Co.

BUSES, ELECTRIC
Delta-Star Electric Div., H. K. Porter Co. (Delaware)
I-T-E Circuit Breaker Co.
Westinghouse Electric Corp.

BUSES, AUTOMOTIVE, DIESEL-ENGINED
Mack Trucks, Inc.

BUSHINGS, BRONZE
American Brake Shoe Co., National Bearing Div.
Ampco Metal, Inc.—"AMPCO" Bearings, Inc.
Flood City Brass & Electric Co.
Gibraltar Equipment & Mfg. Co.
Imperial-Cantrell Mfg. Co. — "IC"
Jeffrey Mfg. Co.
Johnson Bronze Co.
Kelly Manufacturing Co.
Keystone Carbon Co.
Marathon Coal Bit Co. Inc.—"NAIL CITY"
Penn Machine Co.
Bertrand P. Tracy Co.
Walworth Co.

Works better with less work . . .

The LONG

Lo-Rope BELT CONVEYOR

Easier, faster to assemble!

Easier, faster to move!

Easier, faster to extend!

Easier, faster to operate!

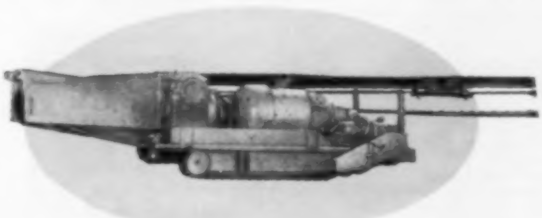
Patents Pending

And it's easy to intersperse LONG Lo-Rope structure with your existing rigid structure and terminals

With its entirely different design, the LONG Lo-Rope offers a number of important operating and safety features not previously available.

For example—in this construction, the wire rope is located below the carrying belt and carrying idlers. The idlers rock (not swing) in the direction of belt travel, thus providing automatic self-training of the belt in both directions. Adjustable height platform rocker support stands minimize blocking and level belt automatically. The deep troughing angle (27°) reduces spillage and permits wider spacing of idlers. There are no side obstructions at carrying belt level, so handling men and supplies is easier and much safer. And with the Lo-Rope, maximum head room is assured as carrying surface of belt may be as low as 9" from the mine floor.

For details on the Lo-Rope Belt Conveyor, write us today. Or better yet, install a test section of Lo-Rope the next time you make a belt extension and learn first hand why it works better with less work.



LONG Belt Conveyor Mobile Drive Units

Self-tramming for easy moves. Available in units up to 40 HP with either snub or tandem drive units for use with Lo-Rope or any other type of belt conveyor.

The **LONG** *Company*
Oak Hill, W. Va.

BUSHINGS, ELECTRICAL

Imperial-Cantrell Mfg. Co.—"IC"
National Electric Products Co.

BUSHINGS, ELECTRICAL HIGH-VOLTAGE

Ohio Brass Co.

BUSHINGS, IRON

Keystone Carbon Co.

BUSHINGS, RUBBER

United States Rubber Co.

CABLE, ALUMINUM

Reynolds Metals Co.

CABLE, ARMORED

General Cable Corp.
Rockbestos Products Corp.
Simplex Wire & Cable Co.—"CONDEX," "C-L-X CONTINUOUS IMPERVIOUS"

CABLE, ASBESTOS-COVERED

American Steel & Wire Div., U. S. Steel Corp.—"AMERBESTOS"
Collyer Insulated Wire Co.
Ensign Electric & Mfg. Co.
John Flocker & Co.
Flood City Brass & Electric Co.
General Cable Corp.—"SAFETY MI"
General Electric Co., Construction Materials Div.
Guyan Machy. Co.
National Electric Products Co.
National Mine Service Co.
Okonite Co.
Phelps Dodge Copper Products Co.
Rockbestos Products Corp.—"ROCKBESTOS A.V.C."
Triangle Conduit & Cable Co. Inc.

CABLE, ELECTRICAL

M. Glosser & Sons, Inc.
Schroeder Brothers Corp.

CABLE, FEEDER, BARE, STRANDED

Aluminum Company of America
American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
Circle Wire & Cable Corp.
Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"
John Flocker & Co.
General Cable Corp.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
National Mine Service Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Rome Cable Corp.
Triangle Conduit & Cable Co. Inc.

CABLE, FEEDER, COPPER, BARE AND STRANDED

Phelps Dodge Copper Products Co.
Rome Cable Corp.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.

CABLE, FEEDER, COPPER AND COPPER CLAD, BARE AND STRANDED

American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Circle Wire & Cable Corp.
Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"
John Flocker & Co.
General Cable Corp.
National Mine Service Co.
Triangle Conduit & Cable Co. Inc.

CABLE, INSULATED, BOREHOLE

American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
Circle Wire & Cable Corp.
Ensign Electric & Mfg. Co.
John Flocker & Co.
General Cable Corp.
Kaiser Aluminum & Chemical Sales, Inc.
National Mine Service Co.
Okonite Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co., Inc.

CABLE, INSULATED, COMMUNICATION, CONTROL

American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
The Ansonia Wire & Cable Co.—"ANKOSEAL"
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
Copperweld Steel Co., Wire & Cable Div. — "COPPERWELD"
John Flocker & Co.
General Cable Corp.
General Electric Co. Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
National Electric Products Co.
Okonite Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Rockbestos Products Corp.—"ROCKBESTOS P. N. R."
Rome Cable Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.

CABLE, INSULATED, HIGH-VOLTAGE DISTRIBUTION

Aluminum Company of America
American Steel & Wire Div., U. S. Steel Corp., "TIGER BRAND"
Anaconda Wire & Cable Co.
The Ansonia Wire & Cable Co.—"ANKOSEAL"
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
Copperweld Steel Co., Wire & Cable Div. — "COPPERWELD"
John Flocker & Co.
Flood City Brass & Electric Co.
General Cable Corp.—"GENCORONE," "BUTARONE"
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
National Electric Products Co.
Okonite Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Rome Cable Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.
Western Insulated Wire Co.—"BRONCO 66"

CABLE, INSULATED, HIGH VOLTAGE, MINE POWER

Anaconda Wire & Cable Co.

CABLE, INSULATED, LOW-VOLTAGE DISTRIBUTION AC AND DC

Aluminum Company of America
American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
The Ansonia Wire & Cable Co.—"ANKOSEAL"
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
Copperweld Steel Co., Wire & Cable Div. — "COPPERWELD"
John Flocker & Co.
Flood City Brass & Electric Co.
General Cable Corp.—"SUPER-SHEATH," "GUARDIAN"
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
Okonite Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Rome Cable Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.
Western Insulated Wire Co.—"BRONCO 66"

CABLE, INSULATED, SUBMARINE

American Steel & Wire Div., U. S. Steel Corp.—"AMARINE"
Anaconda Wire & Cable Co.
The Ansonia Wire & Cable Co.—"ANKOSEAL"
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.
Guyan Machy. Co.
Kaiser Aluminum & Chemical Sales, Inc.
Okonite Co.
Phelps Dodge Copper Products Co.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.

CABLE, LEAD-SHEATHED

General Cable Corp.
Kaiser Aluminum & Chemical Sales, Inc.
Rockbestos Products Corp.

CABLE, REWIRING

National Mine Service Co.

CABLE, SHOTFIRING

American Cyanamid Co., Explosives and Mining Chemicals Dept.
American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
Circle Wire & Cable Corp.
E. I du Pont de Nemours & Co., Inc., Explosives Div.
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
King Powder Co., Inc.
Mosebach Electric & Supply Co.
National Mine Service Co.
Okonite Co.
Olin-Mathieson Chemical Corp., Explosives Div.
Rome Cable Corp.
The Salem Tool Co.—"SALEM"
Simplex Wire & Cable Co.

CABLE, SIGNAL

The Ansonia Wire & Cable Co.—"ANKOSEAL"

CABLE, TELEPHONE

American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Anaconda Wire & Cable Co.
The Ansonia Wire & Cable Co.—"ANKOSEAL"
John Flocker & Co.
General Cable Corp.—"SUPER-TEL"
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
Okonite Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.

CABLE, TRAILING, SHOCK ABSORBERS

Mosebach Electric & Supply Co.

CABLE, TRAILING, 2,200 V AND UP

American Steel & Wire Div., U. S. Steel Corp.—"AMERCLAD"
Circle Wire & Cable Corp.
John Flocker & Co.
General Cable Corp.—"SUPERSERVICE"
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
Okonite Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.

CABLE, TRAILING, STRIP AND QUARRY

Anaconda Wire & Cable Co.

CABLE, TRAILING, UNDERGROUND MINING UNITS

American Steel & Wire Div., U. S. Steel Corp.—"AMERCLAD"
Anaconda Wire & Cable Co.
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
Ensign Electric & Mfg. Co.
John Flocker & Co.
Flood City Brass & Electric Co.
General Cable Corp.—"SUPERSERVICE"
General Electric Co., Construction Materials Div.
Joy Mfg. Co.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
National Mine Service Co.
Okonite Co.
John A. Roebling's Sons Corp., Sub. of Colorado Fuel & Iron Corp.
Rome Cable Corp.—"ROME 60"
Simplex Wire & Cable Co.
Triangle Conduit & Cable Co. Inc.
Western Insulated Wire Co.—"BRONCO 66"

CABLE, WEATHERPROOF ALUMINUM

Kaiser Aluminum & Chemical Sales, Inc.

CABLE ACCESSORIES, HIGH VOLTAGE

G & W Electric Specialty Co.
Ohio Brass Co.

CABLE ASSEMBLIES

Bergen Wire Rope Co.

CABLE CLAMPS

Crosby Laughlin Div., American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Holub Industries, Inc.
Ohio Brass Co.
Ore Reclamation Co.

(Continued on p 206)

The Wellington plant takes its place in the long list of A & G success stories. Should you ever want to start with unworked earth . . . and take over a completed mine ready for profitable operation, simply put the complete responsibility in the hands of A & G. We welcome that kind of assignment.

SCOPE OF A & G SERVICES

- Design and construction of new plants and their various units
- Organization, operation and management of mines
- Reconstruction, revamping and improvement of existing plants
- Below ground modernization and mechanization
- General consulting work on power, equipment, operation and varied mining problems
- Evaluation for financing, fire loss and taxation

Vibrating screen shakes water and sand from coarse coal. Sand suspended in water is used to float lighter coal away from heavier rock and foreign matter (ash-sulphur, etc.). Coal is then crushed prior to shipment to Geneva Works, Provo, Utah.

DESIGN · BUILD · OPERATE

A&G

"TOP OF THE FIELD"

ALLEN & GARCIA CO.

Consulting and Construction Engineers

332 S. MICHIGAN AVE., CHICAGO 4, ILL.

A loaded railroad car every 8 minutes is the rate at which the Wellington Coal Cleaning Plant can turn out cleaned coal destined for Geneva Works.

What we learned about

from salesmen's

This 5′ x 16′ vibrating shaker has four segments—all made from Stainless Steel. Top impact segment processes about 40,000 tons before replacement. Bottom three segments process about *120,000* tons before replacement. In addition, there is very little blinding.

coal preparation costs

call reports

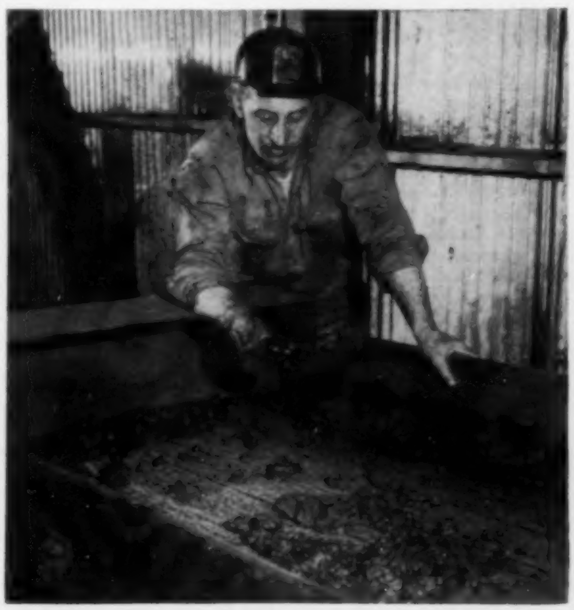
WE DON'T ARGUE the fact that Stainless Steel chutes, screens and other equipment have what appears to be high initial cost. Why, then, do so many coal preparation plants use Stainless Steel for chutes, screens, and other equipment if the initial cost of Stainless equipment is higher than other materials? The answer seems to be that *they can't afford the cheap materials!*

A check of salesmen's call reports reveals this: the companies that keep the most accurate cost records are the ones that use the highest percentage of Stainless Steel equipment. This bears out our contention that Stainless Steel equipment is much cheaper in the long run. In fact, wherever there is a situation involving severe abrasion and corrosion (as in corrosive wash water), *nothing* can equal Stainless Steel in its ability to process *more tons of coal per dollar of equipment cost.*

Naturally, you get the most for your money when you install Stainless Steel equipment right at the beginning, in new equipment. But it's never too late to start saving; and you can buy Stainless Steel strip and sheets right from your local steel warehouse for use in chutes and the like. Make it *USS* Stainless Steel to be sure of service-tested quality.

USS is a registered trademark

Stainless Steel outlasts original chutes seven to one . . . and then some! In actual side-by-side tests, this Stainless Steel chute outlasted seven non-stainless chutes, and the Stainless chute was still in good condition. This plant estimated that a $900 investment in Stainless Steel saved $30,000 in replacements! And because of Stainless Steel's slideability, no build-up disrupted operations.



This Stainless Steel dewatering sludge screen vibrates at 1,200 rpm, will process more than 200,000 tons of coal in its average 14-month service life. Operators of this plant are also impressed by the way Stainless works for them when the plant is *shut down.* It doesn't corrode or blind, is always ready to go into service again.

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

CABLE CONNECTORS, ELECTRICAL

Anaconda Wire & Cable Co.
Albert & J. M. Anderson Mfg. Co.—"EITHEREND"
Burndy Corp.—"HYLUGS," "HYLINKS"
Crouse-Hinds Co.
Delta-Star Electric Div., H. K. Porter Co., (Delaware)
Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Erico Products, Inc.—"CAD-WELD"
Ensign Electric & Mfg. Co.
Guyan Machy. Co.
Joy Mfg. Co.
Magnetic Engrg. & Mfg. Co.
Mosebach Electric & Supply Co.
National Electric Products Co.
Ohio Brass Co.
Tweco Products, Inc.—"SOL-CON," "MECCON"
West Virginia Armature Co.

CABLE CONTROLS

Caterpillar Tractor Co.
Continental Copper & Steel Industries, Inc., Wooldridge Div.—"CONTINENTAL WOOLDRIDGE"

CABLE FAULT-FINDERS, PROOF TESTERS

Electrical Distributors Co.

CABLE HANGERS

American Mine Supply Co.
Ohio Brass Co.

CABLE PROTECTORS

Standard Devices Co.

CABLE REELS, LOCOMOTIVE

Jeffrey Mfg. Co.
West Virginia Armature Co.

CABLE REELS, MINING-MACHINE, SHUTTLE CAR

Dooley Brothers
Jeffrey Mfg. Co.

CABLE REELS, SHOTFIRING

J. V. Hammond Co.
King Powder Co., Inc.

CABLE-REPAIR SERVICE

Cable Vulcanizing Shop, Inc.

CABLE SPLICERS

American Mine Door Co.—"QUICK-ON"
Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Ensign Electric & Mfg. Co.
Erico Products, Inc.—"CAD-WELD"
Flood City Brass & Electric Co.
G & W Electric Specialty Co.
Mine Safety Appliances Co.—"VELOCITY-POWER"
Minnesota Mining & Mfg. Co.
Mosebach Electric & Supply Co.
National Mine Service Co.
Ohio Brass Co.
Tweco Products, Inc.—"TWECO"
West Virginia Armature Co.

CABLE SUPPORTS, BOREHOLE

Ohio Brass Co.

CABLE SUPPORTS, HORIZONTAL RUNS

Delta-Star Electric Div., H. K. Porter Co. (Delaware)
The Elreco Corp.—"ELRECO"
Ohio Brass Co.

CABLE VULCANIZERS

American Mine Door Co.—"SHALER"
Flood City Brass & Electric Co.
Joy Mfg. Co.
Mine Safety Appliances Co.
Moseback Electric & Supply Co.

CABLEWAYS

Delta-Star Electric Div., H. K. Porter Co. (Delaware)

CAGERS, CAGING EQUIPMENT

C. S. Card Iron Works
Connellsville Mfg. & Mine Supply Co.
Robert Holmes & Bros., Inc.
The Nolan Co.
Robert & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

CAGES

C. S. Card Iron Works
Connellsville Mfg. & Supply Co.
Helmick Foundry-Machine Co.
Robert Holmes & Bros., Inc.
Kanawha Mfg. Co.
Mayo Tunnel & Mine Equipment
The Nolan Co.—"SELF DUMPING"
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Vulcan Iron Works

CAGES, ELEVATOR-TYPE

Connellsville Mfg. & Mine Supply Co.—"PORTAL-CAGE"
Helmick Foundry-Machine Co.
Robert Holmes & Bros., Inc.
Mayo Tunnel & Mine Equipment

CALCIUM CHLORIDE

Columbia-Southern Chemical Corp.
The Dow Chemical Co.—"DOWFLAKE," "PELADOW"
E. I. du Pont de Nemours & Co., Inc.
Fisher Scientific Co.
Fuel Process Co.—"FUPROCO"
Solvay Process Div., Allied Chemical Corp.
Wyandotte Chemicals Corp., Michigan Alkali Div.

CAPACITORS

Cornell-Dubilier Electric Corp.
General Electric Co., Apparatus Sales Div.
Ohio Brass Co.—"VAREX"
Westinghouse Electric Corp.

CAP-LAMP CHARGERS

Mine Safety Appliances Co.
National Mine Service Co.

CAP-LAMP RACKS

Mine Safety Appliances Co.
National Mine Service Co.

CAP LAMPS

Mine Safety Appliances Co.—"EDISON R4"
National Mine Service Co.

CAR BY-PASSERS

American Mine Door Co.—"CANTON"

CAR DUMPERS

Link-Belt Co., Dept. CAMGL-58—"KAR-FLO"

CAR DUMPERS, R. R. ROTARY

Connellsville Mfg. & Mine Supply Co.
Differential Steel Car Co.
Heyl & Patterson, Inc.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT"
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Vulcan Iron Works

CAR HAULS, MINE

Link-Belt Co., Dept. CAMGL-58
Nolan Co.

CAR HAULS, MOVERS, PULLERS, R. R.

The Aldon Co.
Advance Car Mover Co., Inc.—"BADGER," "NEW BADGER," "POWER KING," "POWER BOY"
Gibraltar Equipment & Mfg. Co.
Hewitt-Robins Incorporated—"JONES"
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT"
McNally-Pittsburg Mfg. Corp.
Morse Bros. Machinery Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Webster Mfg. Inc.
Whiting Corp.

CAR HAULS, MOVERS, SPOTTERS, MINE

The Aldon Co.
Connellsville Mfg. & Mine Supply Co.
Fairmont Machinery Co.
Flood City Brass & Electric Co.
Gibraltar Equipment & Mfg. Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Joy Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT"
Morse Bros. Machinery Co.
B. J. Nykerk Corp.—"HAUSHERR"
Sanford Day Iron Works, Inc.
Schroeder Brothers Corp.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Webster Mfg. Inc.
Wilmot Engineering Co.

CAR HAULS, MOVERS, SPOTTERS, MINE, HYDRAULIC

The Nolan Co.
Sanford Day Iron Works, Inc.
W. R. Stamler Corp.

CAR HOLDS, STOPS, MINE

C. S. Card Iron Works
Connellsville Mfg. & Mine Supply Co.
Duquesne Mine Supply Co.
Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
The Nolan Co.

CAR LOADERS

Link-Belt Co., Dept. CAMGL-58

CAR MOVERS

National Mine Service Co.

CAR PASSERS

Mayo Tunnel & Mine Equipment

CAR PULLERS

Clyde Iron Works, Inc.
Link-Belt Co., Dept. CAMGL-58

CAR PULLERS, R. R.

American Engineering Co.—"LO-HED"
Link-Belt Co., Dept. CAMGL-58

CAR RETARDERS, MINE CAR

Connellsville Mfg. & Mine Supply Co.
Fairmont Machinery Co.
Robert Holmes & Bros., Inc.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58 "LINK-BELT"
The Nolan Co.
B. J. Nykerk Corp.—"HAUSHERR"
Sanford Day Iron Works, Inc.
Webster Mfg. Inc.

CAR RETARDERS, R. R.

Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Union Switch & Signal Div. of Westinghouse Air Brake Co.
Webster Mfg. Inc.

CAR SHAKERS, R. R.

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58 "LINK-BELT"
Simplicity Engineering Co.
Stephens-Adamson Mfg. Co.—"CARQUAKE"
Webster Mfg. Inc.

CAR SPOTTERS

Link-Belt Co., Dept. CAMGL-58
The Nolan Co. — "PORTA-FEEDERS"

CAR STOPS

The Aldon Co.
Gibraltar Equipment & Mfg. Co.
The Nolan Co.

CAR STOPS, ELECTRIC

Cheatham Elec. Switching Device Co.

CAR THAWERS

Hauck Mfg. Co.

CAR TRANSFERS, MINE

American Mine Door Co.—"CANTON"
C. S. Card Iron Works
Connellsville Mfg. & Mine Supply Co.

CARS, RAIL, MAN-TRIP, SELF-PROPELLED

Lee-Norse Co.—"MINE PORTAL BUS"

CARS, SHUTTLE, REPAIRS

Leman Machine Co.

CARBIDE METALS, SINTERED

Allegheny Ludlum Steel Corp.

CARBON BLACK

Fisher Scientific Co.
R. T. Vanderbilt Co. Inc.

CARRIERS, MINE EQUIPMENT

Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.

CARRIERS, SHUTTLE-CAR

Salem - Brosius, Inc.—"PHIL-DOLLY"

CARS, BALLAST

Differential Steel Car Co.

CARS, RAIL, AIR-DUMP

C. S. Card Iron Works
Differential Steel Car Co.

CARS, RAIL, MAN TRIP

Bethlehem Steel Co.
C. S. Card Iron Works
Differential Steel Car Co.
Enterprise Wheel & Car Corp.
Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.-"MANVAN"
Sanford Day Iron Works, Inc.
Watt Car & Wheel Co.

CARS, RAIL, MINE

American Car & Foundry Div., ACF Industries, Inc.
Bethlehem Steel Co.
C. S. Card Iron Works
Differential Steel Car Co.
Enterprise Wheel & Car Corp.
Gibraltar Equipment & Mfg. Co.
Helmick Foundry-Machine Co.
Hockensmith Corp.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
Kersey Manufacturing Co., Inc.
Mayo Tunnel & Mine Equipment
Morse Bros. Machinery Co.
Sanford Day Iron Works, Inc.
United States Steel Corp.
Watt Car & Wheel Co.

CARS, RAIL, PERSONNEL, SELF-PROPELLED

Irwin Foundry & Mine Car Co.
Lee-Norse Co.—"MINE JITNEY & MINE SCOOTER," "MINE MECHANIC JITNEY"

Femco Offers Controls and Communication for Modern Mines

PERMISSIBLE LIGHTING RECENTLY INTRODUCED

Femco, Inc., pioneers in mine communication, offers users a line of communication systems for mine haulage, for communication between levels and for cleaning plants. Various control systems for indication and control of existing equipment such as fans, pumps and sub-stations, also are featured.

Permissible mine light systems, designed to illuminate working areas of coal mines between face and loading head now are being marketed. Features of Femco Mine Lighting Systems include a light-weight sturdy design, a quick-starting ballast, portability, ease of installation and maintenance and extremely good overall illumination at low cost.

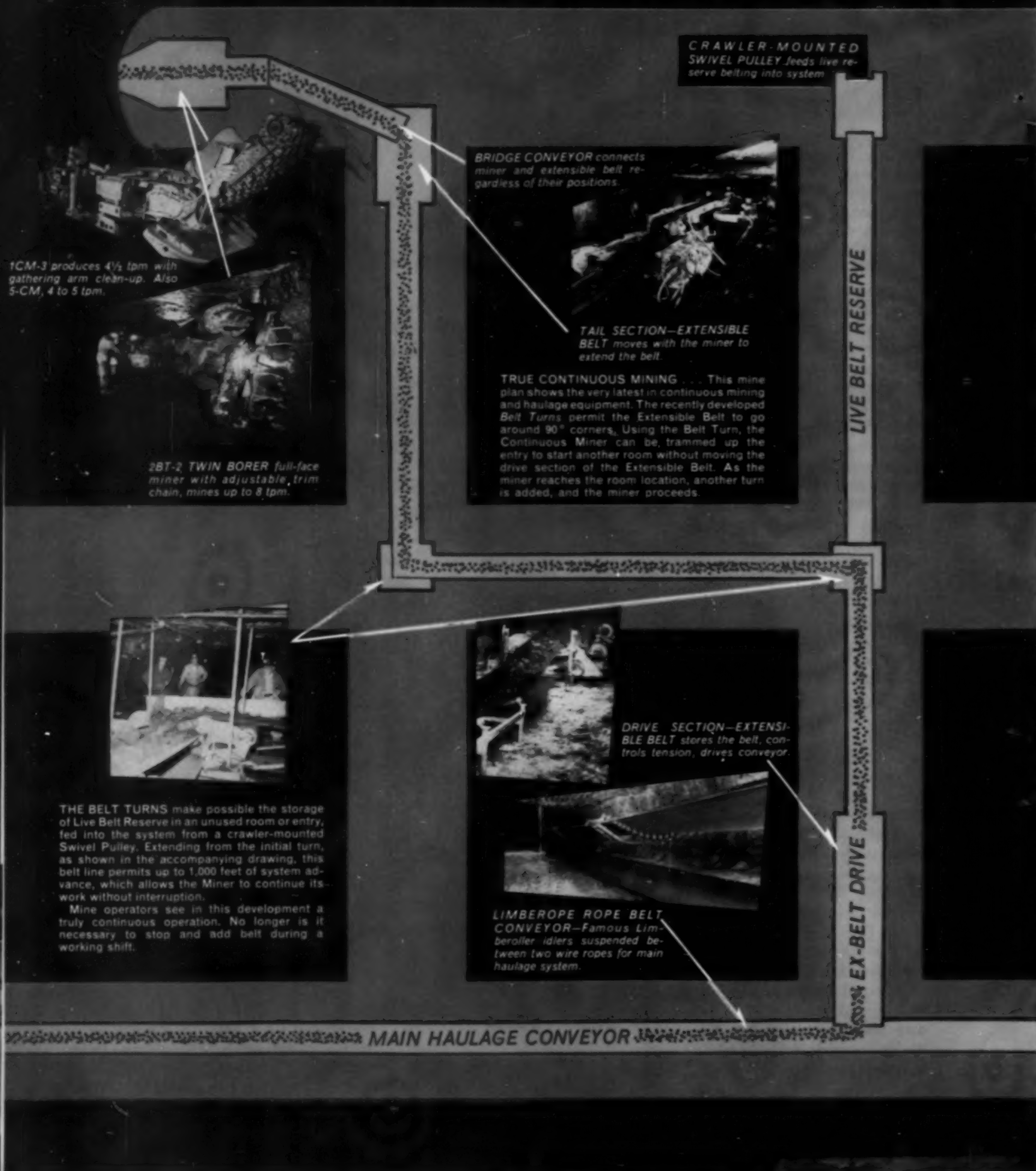
Famous Femco Trolleyphones, Audiophones and Loud Speaking Mine Telephones boast new, more compact components for easier installation anywhere in the mine. Trolleyphone systems are widely used for mine haulage because of their versatility, dependability, low cost and ease of maintenance.

Femco controls include Audio Tone Control or Indication Systems, Circuit Scanner Systems, Carrier Shift Systems, Relay Control Systems and Magnetic Limit Switch Systems. They provide automatic monitoring, indication and control for many different applications throughout the mine. Specific recent installations have included fan signal systems, sub-station control and pump control. Designed for use over existing power lines or only one pair of wires, Femco controls are inexpensive to install.

All Femco components have in common the benefit of advanced engineering for simplicity and compactness of design, fast and dependable operation, ease of installation and maintenance and a long life under heavy-duty use in mining and industry.

MODERN MINING PRACTICE

CONTINUOUS MINING WITH LIVE BELT RESERVE



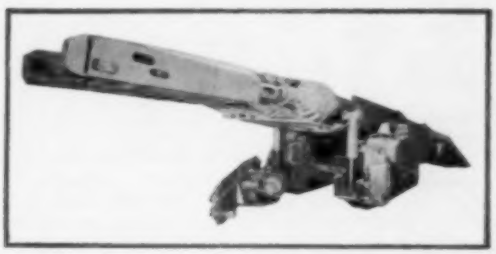
with JOY AC/DC EQUIPMENT

CONVENTIONAL MINING WITH JOY'S "15 SERIES" HIGH PRODUCTION TEAM

FOR 5-FOOT COAL AND OVER

15-RU CUTTER . . . a heavy-duty universal cutter designed for the hardest formations. Cutting motor 75 HP, continuous rating. It bottom cuts, top cuts, shear cuts or anything in between. Arranged for top cutting at 8½, 9½ or 10 ft.

CD-43 TWIN-BOOM DRILL... A one-man adaptation of the high-production, two-man CD-42 drill—operator positions and starts one drill while second is drilling hole—then alternates for continuous operation. Ten or twelve foot steels eliminate auger changes. Capacity 9 to 12 fpm, each drill.



15-BU LOADER . . . loads 15 tons per minute—has swing out service panel for accessibility to all operating and control mechanisms. All motors and drives mounted outside the frame. Model shown is 49½" high . . . lower model, 43" high works 50" coal.

15-SC SHUTTLE CAR . . . 57" high . . . hauls 15 tons in one load for easier faster loading; fewer trips; cheaper haulage. Two 2-speed 25 HP traction motors and one 15 HP pump motor provide power without clutches, torque converters or transmissions.

NEW!

6 WHEEL 18-SC FOR LOW SEAMS

A shuttle car with 6 wheels—hauls a big 4½-tons only 27" high—two traction wheels are in center of car. The car is hinged in middle—while car travels rises and depressions, car bends in middle, keeping all wheels on ground. Conveyor 6' wide, empties in 27 seconds. High tonnage for low seams.

WRITE FOR BULLETIN 250-1

AC MINING EQUIPMENT

All Joy equipment illustrated here is available as AC powered or DC powered. Joy leads in the development of AC equipment—built the first AC cutter back in 1913. Continuous experience in the design and development of AC face equipment since that time means that we have encountered and solved most problems common to AC mechanized mining.

If you are considering an all AC mine—or a single piece of AC equipment—consult a Joy engineer.

JOY MANUFACTURING COMPANY

Oliver Building, Pittsburgh 22, Pa.
In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.

CARS, RAIL, SUPPLY

Bethlehem Steel Co.
C. S. Card Iron Works
Differential Steel Car Co.
Enterprise Wheel & Car Corp.
Gibraltar Equipment & Mfg. Co.
Helmick Foundry-Machine Co.
Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.
Mayo Tunnel & Mine Equipment
Sanford Day Iron Works, Inc.
Watt Car & Wheel Co.

CARS, RAIL, TOOL & REPAIR, SELF-PROPELLED

Joy Mfg. Co.

CARS, RUBBER-TIRED, COAL, SELF-PROPELLED

Joy Mfg. Co.
Kanawha Mfg. Co.
Prime Mover Co. — "M30 PRIME MOVER"

CARS, RUBBER-TIRED, MEN & SUPPLIES, SELF-PROPELLED

Joy Mfg. Co.
Kanawha Mfg. Co.
Lee-Norse Co.—"LEE-NORSE UTILITY TRUCK"
Prime Mover Co. — "M30 PRIME MOVER"

CARS, RUBBER-TIRED TRAILING, COAL

Fred's Welding Service
Goodman Mfg. Co.
Joy Mfg. Co.
Kersey Manufacturing Co., Inc.
Motor Exchange and Supply Co.

CARS, RUBBER-TIRED TRAILING, MEN & SUPPLIES

Kersey Manufacturing Co., Inc.

CARS, SHUTTLE

Goodman Mfg. Co.
Jeffrey Mfg. Co.
Morse Bros. Machinery Co.
National Mine Service Co.—"TOR KAR"

CARS, SHUTTLE, AC & DC

Joy Mfg. Co.

CARS, SHUTTLE, CRAWLER-TYPE

Myers-Whaley Co.—"WHALEY TRANSFER CAR"

CARS, SHUTTLE, DIESEL

Joy Mfg. Co.

CARS, SURGE

Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.
Joy Mfg. Co.

CARTRIDGES, CYLINDRICAL AND FLANGE BALL-BEARING

Bearings, Inc.
Link-Belt Co., Dept. CAMGL-58

CASTINGS, ALLOY

Coast Metals, Inc.

CASTINGS, ABRASION-RESISTANT

Wall Colmonoy Corp.

CASTINGS, BRONZE

American Brake Shoe Co., National Bearing Div.

CASTINGS, GRAY IRON

Link-Belt Co., Dept. CAMGL-58

CASTINGS, HEAT-, CORROSION- & ABRASION-RESISTANT

Electric Steel Foundry Co.

CASTINGS, IRON, MEEHANITE, MODULAR AND STEEL

Farrel-Birmingham Co., Inc.

CASTINGS, MALLEABLE IRON

Link-Belt Co., Dept. CAMGL-58

CASTINGS, MANAGANESE STEEL

Kensington Steel, Div. of Poor & Co.

CASTINGS, NON-FERROUS

American Crucible Prods. Co.

CASTINGS, NON-FERROUS, CENTRIFUGAL

Stoody Co.

CASTINGS, STAINLESS STEEL

Alloy Steel Castings Co.

CASTINGS, STEEL

Falk Corp. — "MOLY-TELASTIC"

CAUSTIC SODA

American Minechem Co.
Columbia-Southern Chemical Corp.
The Dow Chemical Co.
E. I. du Pont de Nemours & Co., Inc.
Fisher Scientific Co.
Wyandotte Chemicals Corp., Michigan Alkali Div.

CEMENT, HIGH-TEMPERATURE

Philip Carey Mfg. Co.—"MW-50," "MW-ONE"
Joseph Dixon Crucible Co.
Johns-Manville—"BLAKITE"
Mexico Refractories Co.—"BONDSET," "HILOSET," "HY-SET"
Norton Co.—"ALUNDUM," "CRYSTOLON"

CENTRIFUGES

Heyl & Patterson, Inc.—"REINEVELD"

CERAMIC COATINGS

Norton Co.—"ROKIDE"

CHAIN, CONVEYOR & ELEVATOR

Acme Chain Co.
American Brake Shoe Co., Amsco Div.—"AMSCO"
American Chain Div., American Chain & Cable Co., Inc.
Bonded Scale & Machine Co.
Chain Belt Co.—"REX"
Diamond Chain Co., Inc.
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
The Daniels Co., Contractors, Inc.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Kensington Steel Div., of Poor & Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT" "RIVETLESS," "PROMAL," "LXS"
McNally-Pittsburg Mfg. Corp.
Mining Machine Parts, Inc.
Ore Reclamation Co.
K. Prins & Associates
W. J. Savage Co.
Taylor-Wharton Co. Div. Harsco Corp.
Transall, Inc.
Watt Car & Wheel Co.
Webster Mfg. Inc.
Wilmot Engineering Co.

CHAIN, FLAT METAL

American Chain Div., American Chain & Cable Co., Inc.

CHAIN, FLIGHT CONVEYOR & ELEVATOR

Acme Chain Corp.
Link-Belt Co., Dept. CAMGL-58
Whitney Chain Co.

CHAIN, MINE CAR SAFETY

American Chain Div., American Chain & Cable Co., Inc.

CHAIN POWER-TRANSMISSION

Bonded Scale & Machine Co.
Browning Mfg. Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Diamond Chain Co., Inc.
Dodge Mfg. Corp.
Jeffrey Mfg. Co.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "LXS," "RC," "SS," "PROMAL," "RIVELTLESS"
McNally-Pittsburg Mfg. Corp.
Mining Machine Parts, Inc.
Morse Chain Co., A Borg-Warner Industry
Transall, Inc.
Whitney Chain Co.

CHAIN REPAIR LINKS

Link-Belt Co., Dept. CAMGL-58
Page Engineering Co.—"TWIN-PIN"

CHAIN, ROLLER

Acme Chain Corp.
Flood City Brass & Electric Co.
Guyan Machy. Co.—"DIAMOND"
Link-Belt Co., Dept. CAMGL-58

CHAIN, SHUTTLE CAR

Link-Belt Co., Dept. CAMGL-58
Whitney Chain Co.

CHAIN, SILENT

Link-Belt Co., Dept. CAMGL-58

CHAIN, WELDED

American Chain Div., American Chain & Cable Co., Inc.
Page Engineering Co.

CHAIN, WELDLESS

American Chain Div., American Chain & Cable Co., Inc.

CHAIN FITTINGS

American Chain Div., American Chain & Cable Co., Inc.
Crosby Laughlin Div., American Hoist & Derrick Co., "CROSBY," "LAUGHLIN"
Electric Steel Foundry Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Page Engineering Co.
Taylor-Wharton Co. Div., Harsco Corp.

CHAIRS, CAGE-LANDING

Nolan Co.

CHOCKS, WHEEL, SAFETY

The Aldon Co.

CHUTES

American Brake Shoe Co., Amsco Div.—"AMSCO"
The Daniels Co., Contractors, Inc.
Enterprise Wheel and Car Corp.
Fairmont Machinery Co.
Helmick Foundry-Machine Co.
Hendrick Mfg. Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
L. O. Koven & Bro., Inc.
Link-Belt Co., Dept. CAMGL-58
Lippman Engrg. Works Inc.
McNally-Pittsburg Mfg. Corp.
Meckum Engr. Co.
Ore Reclamation Co.
K. Prins & Associates
Remal/ Mfg. Co. Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Stephens-Adamson Mfg. Co.
Thomas Engineering & Construction Co.
Transall, Inc.
Wilmot Engineering Co.

CHUTES, DIVERSION, COAL LOADING

The Daniels Co., Contractors, Inc.
Fairmont Machinery Co.
Helmick Foundry-Machine Co.
Robert Holmes & Bros., Inc.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Ore Reclamation Co.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Schroeder Brothers Corp.
Thomas Engineering & Construction Co.
Wilmot Engineering Co.

CIRCUIT-BREAKER ENCLOSURES

Circuit Protective Devices Dept., General Electric Co.

CIRCUIT BREAKERS

Cutler-Hammer, Inc.—"UNIT"

CIRCUIT BREAKERS, AIR

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"RUPTAIR"
Crouse-Hinds Co.
Dooley Brothers
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.
Joy Mfg. Co.
National Mine Service Co.
Westinghouse Electric Corp.

CIRCUIT BREAKERS, OIL

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
General Electric Co., Apparatus Sales Div.
Westinghouse Electric Corp.

CIRCUIT BREAKERS, MOLDED-CASE

Circuit Protective Devices Dept., General Electric Co.

CIRCUIT INTERRUPTORS, TRAILING CABLE

Joy Mfg. Co.
Ohio Brass Co.—"MAGNA-TRIP"

CIRCULATING OIL SYSTEMS

Farval Corp.—"LUBRIVAL"

CLAMPS

B. F. Goodrich Industrial Products Co.—"PUNCHLOK"

CLAMPS, FUSE

Bussmann Mfg. Div., McGraw-Edison Co.—"BUSS"
Holub Industries, Inc.

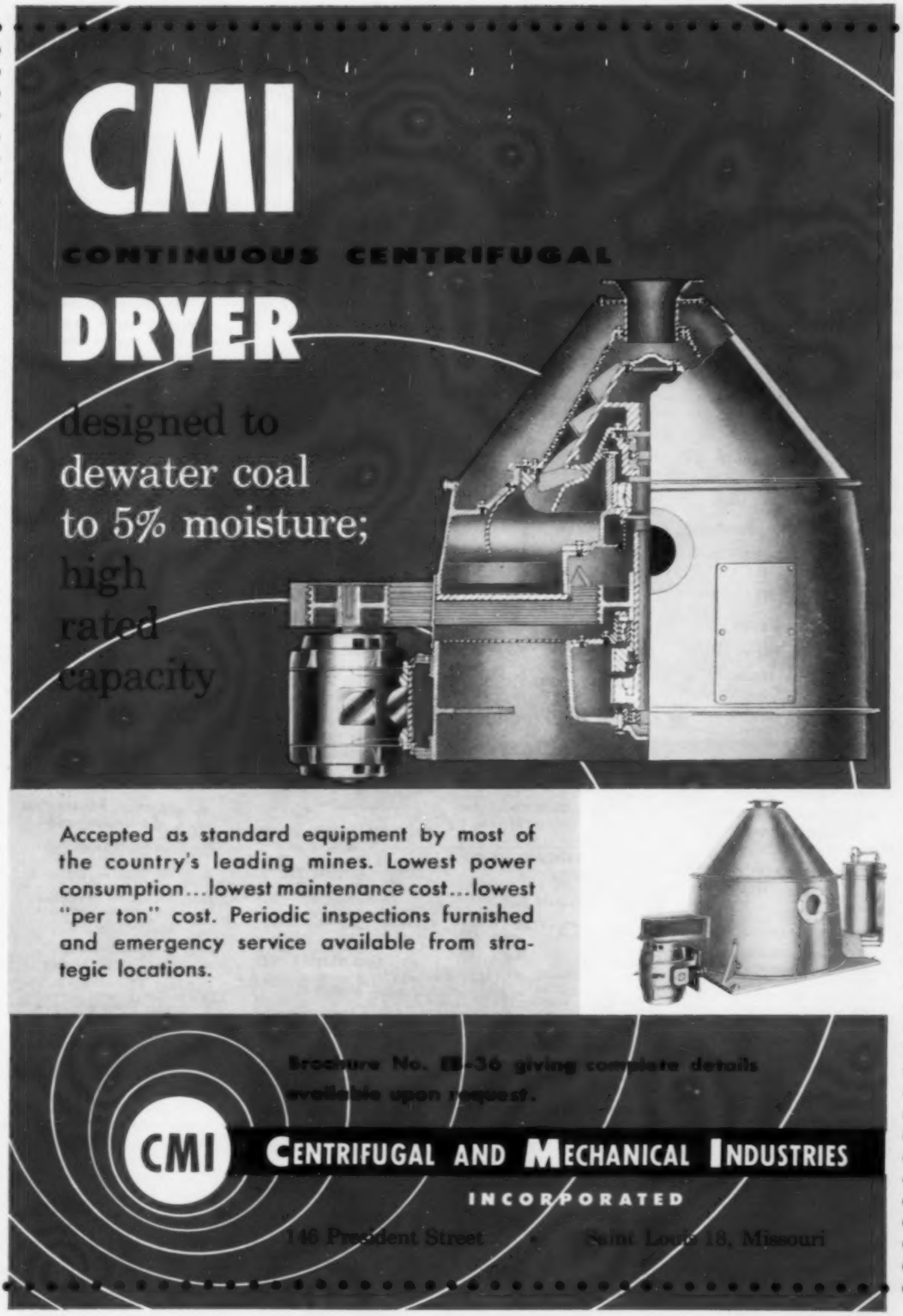
CLAMPS, FUSE & TEST

Circuit Protective Devices Dept., General Electric Co.
Ideal Industries, Inc.
Martindale Electric Co.
Trico Fuse Mfg. Co.—"KLIPLOK"

CLAMSHELLS

Electric Steel Foundry Co.
Koehring Div. of Koehring Co.
Marion Power Shovel Co., A Div. of Universal Marion Corp.
The Thew Shovel Co.—"LORAIN"

(Canada) Limited, Galt, Ontario.



Unit Crane & Shovel Corp.

CLARIFIERS

Eimco Corp.

CLARIFIERS, EFFLUENT, WASTE WATER

Link-Belt Co., Dept. CAMGL-58

CLASSIFIERS, HYDRAULIC

Bird Machine Co.—"BIRD"
Nelson L. Davis Co.—"NELDCO"
The Deister Concentrator Co.—"CONCENCO"
Deister Machine Co.
Denver Equipment Co.—"DENVER"
Dorr-Oliver, Inc.
Link-Belt Co., Dept. CAMGL-58
Peterson Filters & Engineering Co.
Smith Engineering Works
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.—"HYDROTATOR"
Western Machinery Co.—"WEMCO"
Wilmot Engineering Co.

CLASSIFIERS, MECHANICAL

Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"AKINS"
Denver Equipment Co. — "DENVER"
Dorr-Oliver, Inc.
Eagle Iron Works
Kennedy Van Saun Mfg. & Engrg. Corp.
Link-Belt Co., Dept. CAMGL-58
Morse Bros. Machinery Co.—"TRUELINE"
Straub Mfg. Co., Inc.
Western Machinery Co.—"WEMCO"

CLEANERS, MOTOR

American Minechem Co.—"ELMO," "MACMO"

CLEANERS, STEAM

Clayton Mfg. Co.—"CLAYTON-KERRICK"
Homestead Valve Mfg. Co.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.

CLEANERS, ULTRASONIC

General Nuclear Corp.

CLEANING COMPOUNDS, STEAM CLEANING

Homestead Valve Mfg. Co.

CLOTH, ELECTRIC INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

CLOTHING, PROTECTIVE

American Optical Co., Safety Products Div.
B. F. Goodrich Industrial Products Co.
Pulmosan Safety Equip. Co.

CLUTCH FACINGS

Raybestos Manhattan, Inc., Manhattan Rubber Div.
S. K. Wellman Co.—"VELVE-TOUCH FERAMIC," "VELVETOUCH CERAMIC"

CLUTCHES, AIR

Dodge Mfg. Corp.—"AIR-GRIP"

CLUTCHES, AUTOMATIC

Hewitt-Robins Incorporated
Marland One-Way Clutch Co.
Twin Disc Clutch Co.

CLUTCHES, ELECTRIC

I-T-E Circuit Breaker Co.

CLUTCHES, FRICTION

Dodge Mfg. Corp.—"DIAMOND D," "ROLLING GRIP"
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Morse Chain Co., A Borg-Warner Industry—"TORQUE LIMITERS"
Twin Disc Clutch Co.

CLUTCHES, HYDRAULIC

American Blower, Div. of American-Standard

CLUTCHES, JAW

Link-Belt Co., Dept. CAMGL-58

CLUTCHES, MAGNETIC

Cutler-Hammer, Inc.
Dynamatic Div. Eaton Mfg. Co.

CLUTCHES, MAGNETIC, FRICTION

Dynamatic Div., Eaton Manufacturing Co. — "DYNA-TORQ"

CLUTCHES, OVERRUNNING

Marland One-Way Clutch Co.
Morse Chain Co., A Borg-Warner Industry — "CAM CLUTCHES"
Joy Mfg. Co.

CLUTCHES, SYNCHRONIZING

Zurn Industries, Inc., Mechanical Power Transmission Div. —"SYNCHROGEAR"

COAL ANALYSIS LABORATORIES

Commercial Testing & Engineering Co.
Robert Holmes & Bros., Inc.
Warner Laboratories, Inc.

COAL BREAKERS, AIR

Cardox Corp.
Olin-Mathieson Chemical Corp., Explosives Div. — "ARMSTRONG"

COAL BREAKERS, CO_2

Cardox Corp.

COAL BREAKERS, CHEMICAL

Cardox Corp.

COAL INSPECTION

Commercial Testing & Engineering Co.

COAL SAMPLING

Commercial Testing & Engineering Co.

COATINGS, BUILDING, ROOFS

Philip Carey Mfg. Co.
Johns - Manville — "ASBESILE," "AQUADAM," "REGAL"
Pittsburgh Plate Glass Co.—"PITTSBURGH"
The Ruberoid Co.
Stonhard Co. Inc.
Warren Refining & Chemical Co. — "STORM KING," "STORM KING PLUS," "STORM KING ALUMINUM"

COATINGS, CAST PIPE

Goodyear Tire & Rubber Co., Industrial Prods. Div.
Stonhard Co. Inc.

COATINGS, HEAT RESISTANT

Rust-Oleum Corp.

COATINGS, LIQUID STAINLESS-STEEL

Slip-On, Inc.

COATINGS, MINE ROOF, RIBS

American Minechem Co. — "ROOFSKIN"
Stonhard Co. Inc.

COATINGS, PERMANENT STOPPINGS

American Minechem Co.—"STOPPERSKIN"
Stonhard Co. Inc.

COATINGS, PROTECTIVE, CORROSION-PREVENTIVE

Minnesota Mining & Mfg. Co. —"SCOTCHRAP"

COATINGS, PROTECTIVE, RUST-PREVENTIVE

Amercoat Corp. — "AMERCOAT," "DIMETCOAT"
American Minechem Co.
Ashland Oil & Refining Co.—"ASHLAND TECTYL"
Philip Carey Mfg. Co.
Cities Service Oil Co.
Joseph Dixon Crucible Co.
Dow Corning Corp.
E. I. du Pont de Nemours & Co., Inc.
Esso Standard Oil Co.—"RUST-BAN"
B. F. Goodrich Chemical Co.—"GEON"
Johns - Manville — "INSULKOTE"
Keystone Lubricating Co.
Magic Chemical Co.—"MAGIC-VULC"
Master Bronze Powder Co., Inc. —"DERUSTO" "DERUSTO GALV-A-GRIP"
Pittsburgh Plate Glass Co.—"PITTSBURGH"
The Ruberoid Co.
Rust-Oleum Corp.
Shell Oil Co.
Sika Chemical Corp.—"SIKA-SEAL"
Standard Oil Co. (Ind.)
Stonhard Co., Inc.—"SUPER STONECREST"
United States Rubber Co.
Valvoline Oil Co., Div. Ashland Oil & Refining Co.
Warren Refining & Chemical Co. —"WARCO"
Wilbur & Williams Co.—"TOT-RUST"

COATINGS, R. R.-CAR

American Minechem Co.—"HOPPERCOAT"

COATINGS, REFRACTORY

Mexico Refractories Co. — "MEXICAN," "SPRAY MIX," "SUPER MASTIC," "HELSPOT LADLE WASH," "HEKSKOTE"

COATINGS, WATER SEALING

Philip Carey Mfg. Co.
Johns - Manville — "INSULKOTE," "ZEROKOTE"
Rust-Oleum Corp.
Sika Chemical Corp.—"SIKA-KOTE"
Stonhard Co., Inc.—"STONTITE"

COIL TESTERS

Flood City Brass & Electric Co.
Martindale Electric Co.

COILS, ARMATURE, FIELD, ETC.

Flood City Brass & Electric Co.
Guyan Machy. Co.
F. R. Hannon & Sons — "HANCO"
Jeffrey Mfg. Co.
National Electric Coil Co.
Pennsylvania Electric Coil Corp.
West Virginia Armature Co.
Westinghouse Electric Corp.

COILS, DEMAGNETIZING

Dings Magnetic Separator Co.

COLLIMATORS, VERTICAL

Kern Instruments, Inc.

COMBUSTION, CONTROL SYSTEMS

Canton Stoker Corp.—"SYNCHRO"

COMMUNICATIONS, CARRIER-CURRENT

Femco, Inc.—"TROLLEY-PHONE," "ADALINE," "CAGEPHONE"
General Electric Co., Apparatus Sales Div.
Industrial Physics & Electronics Co.
Mine Safety Appliances Co.—"MINEPHONE," "HOIST-PHONE"
Talk-A-Phone
Union Switch & Signal Div. of Westinghouse Air Brake Co.
Westinghouse Electric Corp.

COMMUNICATIONS, R. R. SIGNAL

Union Switch & Signal, Div. of Westinghouse Air Brake Co.

COMMUNICATORS, INTEROFFICE & PLANT

Industrial Physics & Electronics Co.
Mine Safety Appliances Co.
Talk-A-Phone
Wheeler Electronic Corp., Sub. of Sperry Rand Corp.

COMMUTATOR TOOLS

Holub Industries, Inc.
Ideal Industries, Inc.
Martindale Electric Co.
Ohio Carbon Co.
Snap-on Tools Corp.

COMMUTATORS

Jeffrey Mfg. Co.
West Virginia Armature Co.

COMPOUNDS, COAL-TREATING

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AEROSPRAY 52 BINDER"
American Minechem Co.
Cities Service Oil Co.
Columbia-Southern Chemical Corp.
B. F. Goodrich Chemical Co.—"GOOD-RITE"
Shell Oil Co.
Valvoline Oil Co., Div. Ashland Oil & Refining Co.
Wyandotte Chemicals Corp., Michigan Alkali Div.

COMPOUNDS, DEGREASING

American Minechem Co.
Cities Service Oil Co.
Columbia-Southern Chemical Corp.
E. I. du Pont de Nemours & Co., Inc.
Johns-Manville—"HY-SORB"
Wyandotte Chemicals Corp., Michigan Alkali Div.

COMPOUNDS, GENERAL CLEANING

American Minechem Co.
Martindale Electric Co.
Wyandotte Chemicals Corp., Michigan Alkali Div.

COMPOUNDS, INSULATING

G & W Electric Specialty Co.
General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

COMPOUNDS, PIPE-JOINT

Samuel Cabot, Inc.—"PLAS-GON"
Philip Carey Mfg. Co.—"SEWERITE"
Joseph Dixon Crucible Co.
Esso Standard Oil Co.—"PALUBCO," "THRED-KOTE"
The Garlock Packing Co.
Keystone Lubricating Co.—"VIKE GRAPHITE PLASTIC SEAL," "VIKE WATER-SEAL"
Sika Chemical Corp.—"IGAS"


Get positive lubrication... slash mine operating costs with Lincoln
LUBRICATION SYSTEMS
Whatever your lubricant application requirements may be—an automatic system for above or below ground equipment . . . automatic processing lines . . . positive maintenance of transport equipment . . . Lincoln has the tested cost-cutting solutions.
Lincoln has the most complete line of modern devices and systems on the market, backed by 35 years of engineering experience devoted exclusively to the design and manufacture of lubrication equipment. You can take advantage of Lincoln sales and service facilities anywhere . . . through our coast-to-coast network of leading industrial distributors and 16 Sales and Service Offices.
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POWER-OPERATED DRUM PUMPS
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Complete selection of Air-Motors and Pump Tubes.
GREASE GUNS (Heavy Duty Steel Construction)
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From Hydraulic Ball-In-Head to Self-Tapping.
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Lube Capacities from 30 lbs. to 60 lbs.
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(For Grease, Oil, Air and Water Services)
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High and Low Pressure Models.
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MILWAUKEE 16, WIS. Lincoln Engineering Co. of Wis. 3067 N. 35th Street
PAWTUCKET, R. I. H. G. Davis, Inc. 587 Pawtucket Ave.
PHILADELPHIA 3, PA. Lincoln Engineering Co. 1609 Vine Street
PITTSBURGH, PA. Lincoln Engineering Co. 134-36 S. Whitfield
PORTLAND 14, ORE. Lincoln Engineering Co. of Calif. 2018 S. E. 8th Ave.
TORONTO 13, ONT.

COMPOUNDS, SPRAY-WATER ADDITIVE

American Minechem Co.
The Dow Chemical Co.—"SEPARAN 2610"
Johnson-March Corp.—"COMPOUND MR"

CONCENTRATORS, COAL CLEANING

Link-Belt Co., Dept. CAMGL-58

CONCRETE FLOOR HARDENERS

Stonhard Co., Inc.—"STONTOP"

CONCRETE REINFORCING BARS

H. K. Porter Co., Conners Steel Div.—"CONNORS"

CONCRETE-SPRAYING

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Rome Cable Corp.
Triangle Conduit & Cable Co., Inc.
Youngstown Sheet & Tube Co.—"BUCKEYE"

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Reynolds Metals Co.

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Rome Cable Corp.
Triangle Conduit & Cable Co., Inc.
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Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Holub Industries, Inc.
Ideal Industries, Inc.—"WIRE-NUTS"
The Lincoln Electric Co.—"Q-D"
Minnesota Mining & Mfg. Co.—"SCOTCHLOKS"
National Electric Products Co.
Ohio Brass Co.
Schroeder Brothers Corp.

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Eavenson, Auchmuty & Greenwald

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Cutler-Hammer, Inc.
Dooley Brothers
General Electric Co., Apparatus Sales Div.
F. R. Hannon & Sons—"HANCO"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Ohio Carbon Co.
Schroeder Brothers Corp.
Bertrand P. Tracy Co.
Westinghouse Electric Corp.

CONTACTS, CARBON

Keystone Carbon Co.

CONTACTS, ELECTRICAL, REFACED

Superior Carbon Products, Inc.

CONTACTS, METAL-GRAPHITE

Keystone Carbon Co.

CONTAINERS, RUBBER COLLAPSIBLE

United States Rubber Co.

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Goodman Mfg. Co.
Jeffrey Mfg. Co.—"COLMOL"
Joy Mfg. Co.
Lee-Norse Co.—"LEE NORSE MINER"
National Mine Service Co., Clarkson Div.—"MARIETTA"
Wilcox Mfg. Co.—"WILCOX MINER"

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Leman Machine Co.

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Dravo Corp.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Thomas Engineering & Construction Co.

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Joy Mfg. Co.
Mobile Drilling, Inc.
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Sprague & Henwood

CONTRACTORS, ELECTRICAL-CONSTRUCTION

The Daniels Co., Contractors, Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

CONTRACTORS, GROUTING

Cowin & Co., Inc.
Hoffman Bros. Drilling Co.
Mobile Drilling, Inc.
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Sprague & Henwood

CONTRACTORS, SHAFT-DRILLING

Cowin & Co., Inc.
Pennsylvania Drilling Co.

CONTRACTORS, SHAFT & SLOPE

Cowin & Co., Inc.
The R. G. Johnson Co.

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Flood City Brass & Electric Co.
Foxboro Co.
General Electric Co., Apparatus Sales Div.
F. R. Hannon & Sons—"HANCO"
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Joy Mfg. Co.
Morse Bros. Machinery Co.
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Schroeder Brothers Corp.
Bertrand P. Tracy Co.
Westinghouse Electric Corp.

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Cutler-Hammer, Inc.
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Foxboro Co.
General Electric Co., Apparatus Sales Div.
Hays Corp.
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Industrial Physics & Electronics Co.
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Galigher Co.
Hewitt-Robins Incorporated
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburgh Mfg. Corp.
Pioneer Engineering, Div. of Poor & Co.
Quaker Rubber Div., H. K. Porter Co., Inc.
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Continental Gin Co., Ind. Div.
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(Continued on p 218)

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REPLACEABLE TEETH FOR ALL TYPES
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1540 SOUTH GREENWOOD AVE.
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AMERCLAD

PORTABLE POWER CABLE

types W and G

Amerclad power cable is extremely flexible, and will withstand continual reeling on and off drums. Because of its light weight and great toughness, it is widely used for electric shovels, dredges, cranes, excavating machinery and similar equipment.

Type W is recommended for potentials up to 2000 Volts. It has no shielding or ground wires. Type G is good for 5000 volts. When rated over 2000 volts, the insulated conductors are shielded with PS nonmetallic shielding, and all type G cables contain ground wires.

AMERCLAD

TWIN PARALLEL MINING MACHINE CABLE

types W and G

Compared to two-conductor round cables, Twin Parallel Cables occupy less space on a reel or drum, and are lighter in weight. They are recommended for use up to 600 volts.

Amerclad Twin Parallel Mining Machine Cables feature the AS&W "Bridgewall" construction. This is literally a bridge of neoprene between the two insulated conductors and the ground wire. The "Bridgewall" construction enables this cable to withstand crushing weight and severe abrasion without service interruption. This cable also features dynamically balanced, fully engineered rope-lay conductors to insure equal tension.

AMERCLAD

LOCOMOTIVE GATHERING CABLE

This single-conductor cable is especially designed for gathering-reel type electric mine locomotives. Standard conductors are copper, but they can be furnished with steel wire reinforcing for greater tensile strength. Copper conductors, on the other hand, withstand kinking better and they are easier to splice.

The cable is reinforced with tough seine twine and the flame-resistant Amerprene jacket is lead-sheath vulcanized.

AMERCLAD

2-CONDUCTOR ROUND MINING CABLE

The color-coded conductors are insulated with a heat-resisting rubber compound, then twisted and covered with a reinforced oil-resistant Amerprene jacket. Interstices between conductors are filled with neoprene.

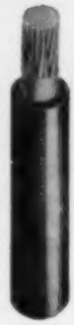
The jacket is flame-resistant and can withstand tremendous abuse in all kinds of weather.

AMERCLAD

PORTABLE CORDS

types SO and SJO

These cords are identical except that type SO has a heavier jacket. This cord is extremely flexible and is designed for use with portable tools and appliances. The tough Amerprene jacket is highly resistant to oil, grease and water. Many different types of cord construction are available.



AMERCLAD

WELDING CABLE

The tremendous number of extremely fine copper wires in this cable provide an unusual degree of flexibility. The cable lies flat without kinking or snarling and there is no undue strain on the operator's wrists. A separator is applied between copper and rubber, so it is easy to strip the insulation to make a splice.

3 great Tigerweld Bonds

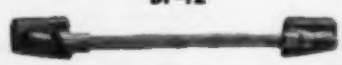
WEDGE-TYPE

The Tigerweld Wedge-Type Bond is primarily designed for quick installation on tracks that may have to be moved, but this durable bond holds so well that many mines use it for permanent installation. It can be installed in a few minutes with a high speed drill and a 3-pound hammer. In spite of its ease of installation, the wedge-type bond holds with a grip that won't shake loose. But if you want to remove the bond from temporary trackage, you can hammer it out as easily as you put it in.

BF-10

The Tigerweld BF-10 has self-clamping terminals to make installation easy. The terminals can be secured to the rails by a few taps of a hammer. And they stay firmly in place while the steel-to-steel weld is made. The BF-10 has great resistance to fatigue stresses. It can be reclaimed and used again and again.

BF-12



The Tigerweld BF-12 Bond is designed for quick, permanent low-resistance installation by welding. Just drive it on the base of the rail and it stays in position ready to weld. No special clamp is necessary. Your maintenance crews can install more bonds per day at lower cost. And once the BF-12 Bonds are installed they're on to *stay!*

All of these bonds are butt-welded. That means that in every case all the wires are electrically connected—permanently—to the solid end piece. Butt-welding will consistently develop almost full strength of the strand on a tensile test to destruction. So always specify Tigerweld Bonds. They're *all* butt-welded!

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DETROIT	General Motors Building	ST. PAUL	First National Bank Building

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Hewitt-Robins Incorporated

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Magic Chemical Co.

CONVEYOR-BELT REPAIR MATERIAL

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Kremser & Sons, Inc., Frank A.
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Scandinavia Belting Co.—"SCANDURA"
Smith Engineering Works
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Transall, Inc.
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Chain Belt Co. — "REX"
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Nelson L. Davis Co. — "NELDCO"
Hewitt-Robins Incorporated
Joy Mfg. Co.
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McNally-Pittsburg Mfg. Corp.
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Transall, Inc.
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General Splice Corp.—"MINET"
Goodyear Tire & Rubber Co.
Industrial Rubber Products Co. (Pa.)
Joy Mfg. Co.
Kremser & Sons, Inc., Frank A.
National Mine Service Co.
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United States Rubber Co.

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Industrial Rubber Products Co. (W. Va.)
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Quaker Rubber Div., H. K. Porter Co., Inc.
Reid Belt & Rubber Co. Inc.
United States Rubber Co.
West Virginia Belt Repairs, Inc.

CONVEYOR-BELTING SPLICING MATERIALS

Armstrong, Bray & Co. — "PLATEGRIP," "HINGED PLATEGRIP"
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General Splice Corp.—"MINET"
Goodyear Tire & Rubber Co.
Industrial Rubber Products Co. (Pa.)
Joy Mfg. Co.
Quaker Rubber Div., H. K. Porter Co., Inc.

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Heintz Mfg. Co.
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Arrowhead Constructors and Engineers, Inc.
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Continental Gin Co., Ind. Div.
Kanawha Mfg. Co.
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Pioneer Engineering, Div. of Poor & Co.
Quaker Rubber Div., H. K. Porter Co., Inc.
Transall, Inc.

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Merrick Scale Mfg. Co. — "WEIGHTOMETER"

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K. Prins & Associates
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Mining Progress, Inc.

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Bonded Scale & Machine Co.—"BONDED"
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Chain Belt Co.—"REX"
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Fairmont Machinery Co.
Goodman Mfg. Co.
Gruendler Crusher & Pulverizer Co.
Hewitt-Robins Incorporated
Heyl & Patterson, Inc.
Irwin Foundry & Mine Car Co
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Joy Mfg. Co.
Kanawha Mfg. Co.
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The Long Co.
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburg Mfg. Corp.
K. Prins & Associates
Roberts & Schafer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.—"REDLER," "ZIPPER"
Transall, Inc.
United States Rubber Co.
Webster Mfg. Inc.
Wilmot Engineering Co.

CONVEYORS, ELEVATING, MINE TRANSFER, CAR LOADING

Bonded Scale & Machine Co.
J. D. Christian Engineers
Fairmont Machinery Co.
Goodman Mfg. Co.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburg Mfg. Corp.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

CONVEYORS, EXTENSIBLE CHAIN

Link-Belt Co., Dept. CAMGL-58
Wilcox Mfg. Co.—"WILCOX"

CONVEYORS, MINE BRIDGE

Goodman Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
The Long Co.—"PIGGY-BACK"
E. F. Marsh Engrg. Co.—"MARCO"

CONVEYORS, MOBILE HEAD, CHAIN

The Long Co.

CONVEYORS, OSCILLATING

Link-Belt Co., Dept. CAMGL-58 — "LINK-BELT," "FLEMOUNT," "COILMOUNT," "TORQMOUNT"

CONVEYORS, PNEUMATIC

Convair

CONVEYORS, PORTABLE

American Conveyor Co. — "CON-VAY-IT"
Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA AUSTIN WESTERN"
Barber-Greene Co.
Baughman Mfg. Co. Inc.—"HI-SPEED"
Bonded Scale & Machine Co.—"BONDED"
J. D. Christian Engineers
George Haiss Mfg. Co., Div., Pettibone Mulliken Corp.
Herold Mfg. Co.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Joy Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
Lippmann Engrg. Works Inc.
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburg Mfg. Corp.
Ore Reclamation Co.
Pioneer Engineering, Div. of Poor & Co.
Stephens-Adamson Mfg. Co.

CONVEYORS, ROPE

Diamond Iron Works, Div. Goodman Mfg. Co.

CONVEYORS, ROPE & BUTTON

Fairmont Machinery Co.
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

CONVEYORS, SCREW

Baughman Mfg. Co., Inc.—"HI-SPEED"
Canton Stoker Corp.—"FLO-TUBE"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Dallas Engineers Inc., Coal-O-Matic Div.
Dayton Automatic Stoker Co.
Jeffrey Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
Link-Belt Co., Dept. CAMGL-58—"QUIK-LINK"
McNally-Pittsburg Mfg. Corp.
Ore Reclamation Co.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Sprout, Waldron & Co., Inc.
Stephens-Adamson Mfg. Co.
Webster Mfg. Inc.

CONVEYORS, SELF-LOADING, MINE

Herold Mfg. Co.
Link-Belt Co., Dept. CAMGL-58

CONVEYORS, SHAKING, MINE

Goodman Mfg. Co.
Herold Mfg. Co.
Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Vulcan Iron Works

CONVEYORS, SHAKING, VIBRATING

Ajax Flexible Coupling Co., Inc. — "AJAX LO-VEYOR"
Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Lecco Machinery & Engineering Co.—"LECCO VIB"
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "FLEXMOUNT," "COILMOUNT," "TORQMOUNT"
Stephens-Adamson Mfg. Co.
Syntron Co.—"VIBRA-FLOW"

CONVEYORS, SPIRAL LOWERING

J. D. Christian Engineers
Robert Holmes & Bros., Inc.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Quaker Rubber Div., H. K. Porter Co., Inc.

CONVEYORS, VIBRATING

Dravo Corp.
Link-Belt Co., Dept. CAMGL-58
Simplicity Engineering Co.

COPYING EQUIPMENT

Charles Bruning Co., Inc.

CORDS, DRILL

Collyer Insulated Wire Co.
Flood City Brass & Electric Co.
General Cable Corp.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
Western Insulated Wire Co.—"BRONCO 66"

CORDS, PORTABLE, ELECTRIC

Collyer Insulated Wire Co.
Cornish Wire Co., Inc.
Ensign Electric & Mfg. Co.
Flood City Brass & Electric Co.
General Cable Corp.
Kaiser Aluminum & Chemical Sales, Inc.
Okonite Co.
Rome Cable Corp.
Western Insulated Wire Co.—"BRONCO 66"

COUPLERS, AUTOMATIC MINE CAR

C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.
Mayo Tunnel & Mine Equipment
National Malleable & Steel Castings Co.—"WILLISON," "SHARON 10"
Ohio Brass Co.
Rydin Railway Equip. Co.

COUPLERS, MINE-CAR

Utility Mine Equipment Co.

COUPLINGS

Webster Mfg., Inc.

COUPLINGS, AIR-LINE

Acme Machinery Co.
C. B. Hunt & Son, Inc.—"QUICK-AS-WINK"
Hose Accessories Co.
Lincoln Engrg. Co.
Marman Div., Aeroquip Corp. —"CONOSEAL"
McDowell Mfg. Co.—"FAST-LINE"
Schroeder Brothers Corp.

COUPLINGS, CHAIN

Acme Chain Corp.
Link-Belt Co., Dept. CAMGL-58—"AC"

COUPLINGS, CLUTCH

Link-Belt Co., Dept. CAMGL-58
Marland One-Way Clutch Co.

COUPLINGS, CONTINUOUS SLEEVE

Zurn Industries, Inc., Mechanical Power Transmission Div.

COUPLINGS, FIRE HOSE

Fyr-Fyter Div.
Hewitt-Robins Incorporated

COUPLINGS, FLEXIBLE

Farrel-Birmingham Co., Inc.
Link-Belt Co., Dept. CAMGL-58
McDowell Mfg. Co.

COUPLINGS, FLEXIBLE-SHAFT, RIGID CHAIN

Dodge Mfg. Corp.—"TAPER-LOCK"
Link-Belt Co., Dept. CAMGL-58

COUPLINGS, FLEXIBLE SHAFT

Ajax Flexible Coupling Co., Inc.
Browning Mfg. Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Diamond Chain Co., Inc.
Elliott Co.
Falk Corp. — "STEELFLEX," "AIRFLEX"
Flood City Brass & Electric Co.
Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Koppers Co., Inc., Metal Products Div.—"FAST'S"
Link-Belt Co., Dept. CAMGL-58 — "RC," "GEARED"
Morse Chain Co., A Borg-Warner Industry — "MORFLEX" (roller, silent, nylon)
Thomas Flexible Coupling Co. —"THOMAS"
Whitney Chain Co.
T. B. Woods Sons Co.
Zurn Industries, Inc., Mechanical Power Transmission Div. —"AMERICAN-AMERIGEAR"

COUPLINGS, FLUID DRIVE

Link-Belt Co., Dept. CAMGL-58

COUPLINGS, FLUID & HYDRAULIC LINES

Aeroquip Corp.—"SELF SEALING"
Blackhawk Mfg. Co.
Champ Industries Inc.
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C. B. Hunt & Son, Inc.—"QUICK-AS-WINK"
Hose Accessories Co.
Link-Belt Co., Dept. CAMGL-58
McDowell Mfg. Co.—"FAST-LINE"
Weatherhead Co., Fort Wayne Div.

COUPLINGS, GROOVED-END PIPE

Gustin-Bacon Mfg. Co. — "GRUVAGRIP," "GRUVA-JOINT," "RIGI-GRIP," "ALUMINUM GRUVA-GRIP"

COUPLINGS, HOSE

Acme Machinery Co.
Aeroquip Corp.
Anchor Coupling Co., Inc.
Carlyle Rubber Co., Inc.
Chicago Pneumatic Tool Co.
Ensign Electric & Mfg. Co.
Franklin Plastics Inc.—"DUR-X PLASTIC"
Goodall Rubber Co.
Goodyear Tire & Rubber Co.
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Hewitt-Robins Incorporated
C. B. Hunt & Son, Inc.—"QUICK-AS-WINK"
Industrial Rubber Products Co. (Pa.)

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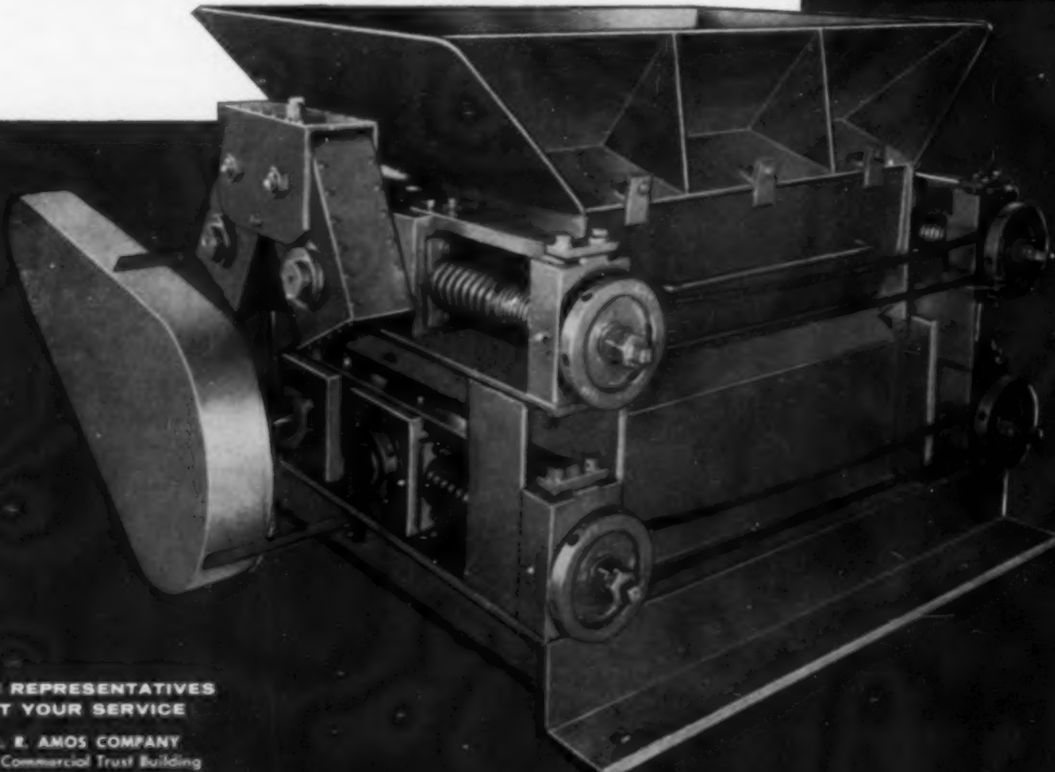
Meet the press of today's market where absolute control of top size is essential



OUR REPRESENTATIVES AT YOUR SERVICE

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American Steel Foundries—
"WEARPACT"
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Hose Accessories Co.
Lincoln Engrg. Co.—"LOK-TITE"
Meckum Eng. Co.
Schroeder Brothers Corp.
Thor Power Tool Co.
United States Rubber Co. "EVERTITE"
Weatherhead Co., Fort Wayne Div.

COUPLINGS, HYDRAULIC

National Mine Service Co.—"NATIONAL"

COUPLINGS, HYDRAULIC-DRIVE

Twin Disc Clutch Co.

COUPLINGS, MAGNETIC-DRIVE

Dynamatic Div., Eaton Mfg. Co.

COUPLINGS, PLAIN END PIPE

Gustin-Bacon Mfg. Co.—"ROL-AGRIP"
Victaulic Co. of America—"VICTAULIC ROUST-A-BOUT"

COUPLINGS, SHAFT

Dodge Mfg. Corp. — "PARA-FLUX"
Link-Belt Co., Dept. CAMGL-58

COUPLINGS, SWIVEL, BRONZE

The Lunkenheimer Co. — "LUNKENHEIMER"

COVERING, FLOOR, STAIR

Minnesota Mining & Mfg. Co. —"SAFETY WALK"

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Link-Belt Speeder Corp.
"Quick-Way" Truck Shovel Co.

CRANES, GANTRY & WALL

American Hoist & Derrick Co.
Shepard Niles Crane & Hoist Corp.

CRANES, JIB & BRACKET

Shepard Niles Crane & Hoist Corp.

CRANES, MOBILE

American Hoist & Derrick Co. —"AMERICAN"
Austin-Western, Construction Equipment Div., Baldwin-Lima-Hamilton Corp.
Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA"
Bucyrus-Erie Co.
Clark Equipment Co., Construction Machinery Div.— "MICHIGAN"
Dravo Corp.
Gar Wood Industries, Inc
Harnischfeger Corp.
Hyster Co. — "KARRY KRANE"
Koehring Div. of Koehring Co.
LeTourneau-Westinghouse Co. —"TOURNAPULL"
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
Orton Crane & Shovel Co.
Ruger Equipment, Inc.— "RUGER"
Schield Bantam Co.
The Thew Shovel Co.— "LORAIN"
Unit Crane & Shovel Corp.

CRANES, RUBBER-TIRED, SELF-PROPELLED

Link-Belt Speeder Corp.

CRANES, SHOP & PLANT

Austin-Western, Construction Equipment Div. Baldwin-Lima-Hamilton Corp.
Guyan Machy. Co.
Harnischfeger Corp.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"SHAW BOX," "LOAD LIFTER"
Morse Bros. Machinery Co.
Robbins & Myers, Inc.—"R & M"
Shepard Niles Crane & Hoist Corp.

CRANES, TRACTOR

Allis-Chalmers Mfg Co., Construction Machinery Div.

CRANES, TRACTOR & TRUCK

Austin-Western, Construction Equipment Div., Baldwin-Lima-Hamilton Corp.
Baldwin-Lima-Hamilton Corp. Construction Equipment Div. —"LIMA"
Clark Equipment Co., Construction Machinery Div.— "MICHIGAN"
The Four Wheel Drive Auto Co.
Gar Wood Industries, Inc.
Harnischfeger Corp.
Insley Mfg. Corp.
Marion Power Shovel Co., a Div. of Universal Marion Corp.

CRANES, TRUCK

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Austin-Western, Construction Equipment Div. Baldwin-Lima-Hamilton Corp.
Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA"

Bucyrus-Erie Co.
Clark Equipment Co., Construction Machinery Div.—"MICHIGAN"
The Four Wheel Drive Auto Co.
Gar Wood Industries, Inc.
Harnischfeger Corp.
Insley Mfg. Corp.
Koehring Div. of Koehring Co.
Link-Belt Speeder Corp. — "ZEPHYRCRANES"
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
Pitman Manufacturing Co. — "HYDR-A-LIFT," "PITMAN MODEL 80"
"Quick-Way" Truck Shovel Co.
Ruger Equipment, Inc. — "RUGER"
Schield Bantam Co.
The Thew Shovel Co.—"LORAIN MOTOCRANE"

CRANES, TRUCK, CHASSIS

Hendrickson Mfg. Co.

CRANES, WHIRLEY

Clyde Iron Works, Inc.

CRAWLER PADS

American Brake Shoe Co., Amsco Div.—"AMSCO"
Kensington Steel, Div. of Poor & Co.

CREOSOTE OIL

Republic Creosoting Co.

CRIB RELEASE BARS

Mining Progress, Inc.

CROSS ARMS

Fluor Products Co.

CROSSING SIGNALS, RAIL, HIGHWAY

American Mine Door Co.
Nachod & U. S. Signal Co.

CRUSHER JAWS

American Brake Shoe Co., Amsco Div.—"AMSCO"
Kensington Steel, Div. of Poor & Co.

CRUSHERS, HAMMER

American Pulverizer Co.
Diamond Iron Works, Div. Goodman Mfg. Co.
Gruendler Crusher & Pulverizer Co.
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Sprout, Waldron & Co., Inc.
Stedman Foundry & Machine Co., Inc.
Sturtevant Mill Co.
Universal Engineering Co.—"BULLDOG"
Williams Patent Crusher & Pulv. Co.

CRUSHERS, IMPACT

American Pulverizer Co.
Nordberg Mfg. Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.

CRUSHERS, JAW

Denver Equipment Co.—"DENVER"
Diamond Iron Works, Div. Goodman Mfg. Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Straub Mfg. Co. Inc.—"KUEKEN"
Universal Engineering Co.—"BULLDOG"

CRUSHERS, LABORATORY

American Pulverizer Co.
Denver Equipment Co.—"DENVER"
Fisher Scientific Co.
Gruendler Crusher & Pulverizer Co.
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Morse Bros. Machinery Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Stedman Foundry & Machine Co., Inc.
Sturtevant Mill Co.
Universal Engineering Co.
Williams Patent Crusher & Pulv. Co.
Wise Co., O. B.

CRUSHERS, REPLACEMENT PARTS

American Brake Shoe Co., Amsco Div.
American Pulverizer Co.
American Steel Foundries—"WEARPACT"
Electric Steel Foundry Co.
Gruendler Crusher & Pulverizer Co.
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Kensington Steel, Div. of Poor & Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Pioneer Engineering, Div. of Poor & Co.
Stedman Foundry & Machine Co., Inc.
Taylor-Wharton Co. Div. Harsco Corp.
The Tool Steel Gear & Pinion Co.
Universal Engineering Co.
Williams Patent Crusher & Pulv. Co.

CRUSHERS, RING

American Pulverizer Co.
Gruendler Crusher & Pulverizer Co.
Jeffrey Mfg. Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Simplicity Engineering Co.
Stedman Foundry & Machine Co., Inc.
Stephens-Adamson Mfg. Co.—"KNITTEL"
Williams Patent Crusher & Pulv. Co.

CRUSHERS, ROLL

Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA AUSTIN WEST-

ERN"
Bonded Scale & Machine Co. —"BONDED"
Denver Equipment Co.—"DENVER"
Diamond Iron Works, Div. Goodman Mfg. Co.
Eagle Iron Works
Gruendler Crusher & Pulverizer Co.
T. J. Gundlach Machine Co.—"GUNDLACH"
Guyan Machy. Co.
Hewitt-Robins Incorporated
Heyl & Patterson, Inc.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
Link-Belt Co., Dept. CAMGL-58
McLanaghan & Stone Corp.
McNally-Pittsburgh Mfg. Corp.
Morse Bros. Machinery Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Pioneer Engineering, Div. of Poor & Co.
Stephens-Adamson Mfg. Co.
Sturtevant Mill Co.
Traylor Engineering & Mfg. Co.
Universal Engineering Co.
Webster Mfg. Inc.
Williams Patent Crusher & Pulv. Co.
Wilmot Engineering Co.

CRUSHERS, SAMPLE
American Pulverizer Co.
Denver Equipment Co.—"DENVER"
Fisher Scientific Co.
Gruendler Crusher & Pulverizer Co.
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Sturtevant Mill Co.
Williams Patent Crusher & Pulv. Co.

CRUSHERS, TRIPLE-ROLL
McLanahan & Stone Corp.

CRUSHERS, TWO-STAGE
T. J. Gundlach Machine Co., Div. J. M. J. Industires, Inc. —"GUNDLACH"
Kennedy Van Saun Mfg. & Engrg. Corp.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Pennsylvania Crusher Div., Bath Iron Works Corp.
Universal Engineering Corp.—"TWINDUAL"
Williams Patent Crusher & Pulv. Co.

CRUSHING PLANTS, PORTABLE, STATIONARY
Diamond Iron Works, Div. Goodman Mfg. Co.

CRUSHING ROLLS, LABORATORY
Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.

CULVERTS
Republic Steel—"REPUBLIC"

CULVERTS, CORRUGATED-METAL
Armco Drainage & Metal Prod., Inc.

CUPS, GREASE AND OIL
Link-Belt Co., Dept. CAMGL-58
The Lunkenheimer Co.—"ALSEN," "GEM," "PIONEER," "ROYAL," "SENTINEL," "TIGER"

CURTAINS, PLASTIC
Mine Ventilation Systems, Inc.

CUT-OFF MACHINES, ABRASIVE
Allison-Campbell Div., American Chain & Cable Co., Inc. —"CAMBPELL"

CUT-OFF WHEELS, ABRASIVE
Allison-Campbell Div., American Chain & Cable Co., Inc. —"ALLISON"

CUT-OUTS, ELECTRICAL
Duquesne Mine Supply Co.
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.

CUT-OUTS, OIL FUSE
G & W Electric Specialty Co.

CUTTER BARS
The Bowdil Co.
Cincinnati Mine Machinery Co. —"CINCINNATI"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Penn Machine Co.
Frank Prox Company Inc.
Bertrand P. Tracy Co.

CUTTER BARS, REBUILDING
Leman Machine Co.

CUTTER CHAINS
The Bowdil Co.
Cincinnati Mine Machinery Co. —"CINCINNATI"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Marathon Coal Bit Co. Inc.—"TRACY"
Penn Machine Co.
Frank Prox Company, Inc.
Bertrand P. Tracy Co.

CUTTER CHAINS, CONTINUOUS MINER
Frank Prox Company, Inc.

CUTTER LOADERS, DRUM
Herold Mfg. Co.

CUTTERS, BAR, CABLE, CHAIN, ROD, WIRE ROPE, ETC.
H. K. Porter, Inc.

CUTTING MACHINES
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Morse Bros. Machinery Co.

CUTTING MACHINES, REBUILT
Leman Machine Co.

CUTTING TORCHES—See Welding, Cutting Torches, Outfits

CUTTING MACHINES, CONVERTED TRACK TO RUBBER
Lee-Norse Co.
Leman Machine Co.

CYCLONES, AIR TREATMENT
Combustion Engineering, Inc., Raymond Div.
The Ducon Co. Inc.
Hardinge Co., Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Western Precipitation Corp.—"MULTICLONE"

CYCLONES, CARBIDE-COATED
Bi-Metal Products Co., Div. of American Alloy Corp.

CYCLONES, WATER TREATMENT
Bird Machine Co.—"BIRD"
Centrifugal & Mech. Industries, Inc.—"CLUST-R-CLONE"
The Daniels Co., Contractors, Inc.
Denver Equipment Co.
Dorr-Oliver, Inc.

Fairmont Machinery Co.
Heyl & Patterson, Inc.
Kanawha Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
McNally-Pittsburg Mfg. Corp.
Peterson Filters & Engineering Co.
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CYLINDERS, AIR
Ledeen, Inc.
Schroeder Brothers Corp.

CYLINDERS, DOOR OPERATORS
Ledeen, Inc.

CYLINDERS, DUMP GATE OPERATORS
Ledeen, Inc.

DENSITY MEASUREMENT
Industrial Nucleonics Corp.—"ACCURAY"

DEMAGNETIZERS
Martindale Electric Co.

DERAILERS
L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.
Miners' Hardware Supply Co.
The Nolan Co.
Sanford Day Iron Works, Inc.

DERAILERS, ELECTRIC, AUTOMATIC & REMOTELY CONTROLLED
American Mine Door Co.
Cheatham Elec. Switching Device Co.

DERRICKS
American Hoist & Derrick Co.
Clyde Iron Works, Inc.

DETECTORS, TRAMP-IRON
General Electric Co., Apparatus Sales Div.
Industrial Physics & Electronics Co.
Stearns Magnetic Products

DETECTORS, MAGNETIC-ELECTRONIC
Dings Magnetic Separator Co.

DETERGENTS, GERMICIDAL
American Optical Co., Safety Products Div.

DETONATOR BOXES, WOOD
King Powder Co., Inc.
Mine Safety Appliances Co.

DETONATORS, ELECTRIC
American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AMERICAN"
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
Hercules Powder Co.
King Powder Co., Inc.
Olin Mathieson Chemical Corp., Explosives Div.
National Powder Co.

DETONATORS, MILLISECOND-DELAY
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
King Powder Co., Inc.
Olin Mathieson Chemical Corp., Explosives Div.—"MINAMAX"
National Powder Co.

DETONATORS, REGULAR-DELAY
Hercules Powder Co.

DETONATORS, SHORT DELAY
American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AMERICAN"
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
King Powder Co., Inc.
National Powder Co.

DETONATORS, SHORT-PERIOD DELAY
Hercules Powder Co.

DETONATORS, STANDARD-DELAY
American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AMERICAN"
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
King Powder Co., Inc.
Olin Mathieson Chemical Corp., Explosives Div.—"VENTLESS"
National Powder Co.

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Hoffman Brothers Drilling Co.
J. K. Smit & Sons
Sprague & Henwood, Inc.

DIAPHRAGMS, PUMPS, VALVES, ETC.
United States Rubber Co.

DIPPER TEETH, BASES, INSERTS, ETC.
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American Steel Foundries—"WEARPACT"
Electric Steel Foundry Co.
H & L Tooth Co.
Kensington Steel, Div. of Poor & Co.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Taylor-Wharton Co. Div., Harsco Corp.

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Electric Steel Foundry Co.
Marion Power Shovel Co., a Div. of Universal Marion Corp.

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Westinghouse Electric Corp.

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G & W Electric Specialty Co.
Joy Mfg. Co.
Ohio Brass Co.
Schroeder Brothers Corp.
Westinghouse Electric Corp.

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DISTRIBUTORS, HYDRAULIC COAL FEED
Deister Machine Co.
Denver Equipment Co.—"DENVER"
Heyl & Patterson, Inc.

DOCKS, LOADING, UNLOADING
Dravo Corp.
Link-Belt Co., Dept. CAMGL-58

DOORS, AIR-POWERED
American Mine Door Co.—"CANTON"

DOORS, FURNACE-OBSERVATION ACCESS
Bigelow-Liptak Corp.

DOORS, INDUSTRIAL STEEL
Steelcraft Mfg. Co.

DOORS, STEEL FIRE
Steelcraft Mfg. Co.

DOORS, MINE
American Mine Door Co.—"CANTON"

DOORS, MINE, AUTOMATIC
American Mine Door Co.—"CANTON"

DRAFT GEAR, RUBBER
Enterprise Wheel and Car Corp.
National Malleable & Steel Castings Co.—"NATIONAL MULTIPAD"

DRAFTING EQUIPMENT, SUPPLIES
Charles Bruning Co., Inc.
Geo-Optic Co., Inc.
Wild Heerbrugg Instruments, Inc.

DRAGLINES, CRAWLER
American Hoist & Derrick Co.—"AMERICAN"
Baldwin-Lima-Hamilton Corp., Construction Equipment Div.—"LIMA"
Bucyrus-Erie Co.
Clark Equipment Co., Construction Machinery Div.—"MICHIGAN"
Gar Wood Industries, Inc.
Harnischfeger Corp.
Koehring Div. of Koehring Co.
Link-Belt Speeder Corp.
Manitowoc Engineering Corp.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
Schield Bantam Co.
The Thew Shovel Co.
Unit Crane & Shovel Corp.

DRAGLINES, RUBBER-TIRED
American Hoist & Derrick Co.—"AMERICAN"
Baldwin-Lima-Hamilton Corp., Construction Equipment Div.—"LIMA"
Bucyrus-Erie Co.
Clark Equipment Co., Construction Machinery Div.—"MICHIGAN"
Gar Wood Industries, Inc.
Harnischfeger Corp.
Koehring Div. of Koehring Co.
Link-Belt Speeder Corp.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
The Thew Shovel Co.
Unit Crane & Shovel Corp.

DRAGLINES, WALKING
Bucyrus-Erie Co.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Page Engineering Co.

DRIER COLUMNS, CARBIDE-COATED
American Alloy Corp.

DRIERS, CENTRIFUGAL
Bird Machine Co.—"BIRD"
Blaw-Knox Co.
Centrifugal & Mech. Industries, Inc.—"C-M-I"
Dorr-Oliver, Inc.
Heyl & Patterson, Inc.
McNally-Pittsburg Mfg. Corp.

DRIERS, CENTRIFUGAL, SCREEN-TYPE SOLID-BOWL
Bird Machine Co.—"BIRD"

DRIERS, CONTINUOUS ROTARY

Hardinge Co., Inc.
Link-Belt Co., Dept. CAMGL-58—"ROTO-LOUVRE" "MULTI-LOUVRE"
Standard Steel Corp.

DRIERS, FLUIDIZED BED

Dorr-Oliver, Inc.
Heyl & Patterson, Inc.

DRIERS, HEAT

Buttner Works, Inc.
J. D. Christian Engineers—"THERMOVEYORS"
Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"SKINNER," "LOWDEN"
Combustion Engineering, Inc., Raymond Div.—"FLASH"
Nelson L. Davis Co.—"NELDCO"
Denver Equipment Co.—"DENVER-STANDARD"
Dravo Corp.
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Link-Belt Co., Dept. CAMGL 58—"ROTO-LOUVRE," "MULTI-LOUVRE"
McNally-Pittsburg Mfg. Corp.
Silver Engineering Works, Inc.—"PARRY TURBULENT ENTRAINMENT"
Western Precipitation Corp.—"HOLO-FLITE"
Westinghouse Electric Corp., B. F. Sturtevant Div.
Wyssmont Co., Inc.—"TURBO-DRYER"

DRILL AUGERS, COAL

Cardox Corp.
Central Mine Equipment Co.
Compton, Inc.
Dooley Brothers
Howells Mining Drill Co.
Kennametal, Inc., Mining Tool Div.
The Leetonia Tool Co.
McLaughlin Mfg. Co., Inc.
Mobile Drilling, Inc.
National Mine Service Co.
Paris Mfg. Co.
The Salem Tool Co.—"McCARTHY"
Schroeder Brothers Corp.
Taylor-Wharton Co. Div., Harsco Corp.
Thor Power Tool Co.

DRILL AUGERS, STRIP OVERBURDEN

Cardox Corp.
Central Mine Equipment Co.
McLaughlin Mfg. Co., Inc.
Mobile Drilling, Inc.
Paris Mfg. Co.
The Salem Tool Co.—"McCARTHY"

DRILL BOXING

The Leetonia Tool Co.

DRILL CORE BARRELS

Mobile Drilling, Inc.

DRILL EXTRACTORS, MAGNETIC

Dings Magnetic Separator Co.

DRILL HEAD

Austin Powder Co.—"AUSTIN AP"

DRILL JUMBOS

Acme Machinery Co.
Chicago Pneumatic Tool Co.
Gardner-Denver Company
Gibraltar Equipment & Mfg. Co.
Ingersoll-Rand Co.—"HYDRA-BOOM"
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Mayo Tunnel & Mine Equipment
B. J. Nykerk Corp.—"HAUSHERR"
Schroeder Brothers Corp.

DRILL PIPE

Davey Compressor Co.
Geo. E. Failing Co., Sub. of Westinghouse Air Brake Co.
Jones & Laughlin Steel Corp.
Mobile Drilling, Inc.
National Supply Company—"SPANGWELD," "DOUBLE SEAL SHRINK THREAD"
National Tube Div., United States Steel corp.—"USS NATIONAL"
Stardrill-Keystone Co.
Varel Mfg. Co., Inc.

DRILL PRESSES

Black & Decker Mfg. Co.
Farrel-Birmingham Co., Inc.
South Bend Lathe Works

DRILL RODS

Mobile Drilling, Inc.

DRILL SHARPENERS

Gardner-Denver Company
Ingersoll-Rand Co.

DRILL STEEL

Acme Machinery Co.
Bethlehem Steel Co.
Brunner & Lay, Inc.
Crucible Steel Co. of America—"VICTOR CRUCIBLE," "KETOS," "ALVA EXTRA," "NU-DIE," "REX," "SPECIAL," "HALCOMB 218"
Davey Compressor Co.
Gardner-Denver Company
Gibraltar Equipment & Mfg. Co.
Howells Mining Drill Co.
Ingersoll-Rand Co.
Joy Mfg. Co.
Marathon Coal Bit Co., Inc.—"IRON CITY," "GARDNER DENVER"
National Mine Service Co.
B. J. Nykerk Corp.—"HAUSHERR"
Schroeder Brothers Corp.
Thor Power Tool Co.
Varel Mfg. Co., Inc.

DRILL STEEL, HOLLOW

Crucible Steel Co. of America—"NU-DIE"

DRILL THREAD BARS

The Leetonia Tool Co.

DRILL TOOLS, CHURN

Spang & Company

DRILLING RIGS

National Supply Co.—"NATIONAL"

DRILLS, AUGER

Mobile Drilling, Inc.

DRILLS, COAL, HAND

Black & Decker Mfg. Co.
Ensign Electric & Mfg. Co.
Howells Mining Drill Co.
The Leetonia Tool Co.
B. J. Nykerk Corp.—"HAUSHERR"
Ohio Brass Co.
Penn Machine Co.
The Salem Tool Co.—"SALEM"
Schroeder Brothers Corp.

DRILLS, COAL, HAND-HELD

Chicago Pneumatic Tool Co.—"WHIPPETT CP"
The Cincinnati Electrical Tool Co.
Ensign Electric & Mfg. Co.
Jeffrey Mfg. Co.
Morse Bros. Machinery Co.
Penn Machine Co.
Schroeder Brothers Corp.

DRILLS, COAL, HAND-HELD HYDRAULIC

Chicago Pneumatic Tool Co.—"CP"
Jeffrey Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Penn Machine Co.
Schroeder Brothers Corp.

DRILLS, COAL, HYDRAULIC

The Long Co.

DRILLS, COAL, MOUNTED SELF-PROPELLED

Bucyrus-Erie Co.
Chicago Pneumatic Tool Co.—"CP"
Dooley Brothers
Jeffrey Mfg. Co.
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Lee-Norse Company—"LEE-NORSE DRILL TRUCK"
Mobile Drilling, Inc.
B. J. Nykerk Corp.—"HAUSHERR"
Paris Mfg. Co.
Penn Machine Co.
The Salem Tool Co.—"McCARTHY"
Stardrill-Keystone Co—"SPEED STAR," "KEYSTONE-FRANKS"
Winter-Weiss Co. — "PORTA-DRILL"

DRILLS, COAL, POST-MOUNTED

Chicago Pneumatic Tool Co.—"CP"
Dooley Brothers
Jeffrey Mfg. Co.
The Leetonia Tool Co.
Morse Bros. Machinery Co.
Penn Machine Co.
The Salem Tool Co.—"SALEM"

DRILLS, COAL RECOVERY

The Salem Tool Co.

DRILLS, CORE

Acker Drill Co. — "HILL-BILLY," "TEREDO," "PACKSACK"
Chicago Pneumatic Tool Co.—"CP"
Geo. E. Failing Co., Sub. of Westinghouse Air Brake Co.
Hoffman Brothers Drilling Co.
Joy Mfg. Co.
Mobile Drilling, Inc.
Pennsylvania Drilling Co.
Reich Bros. Mfg. Co., Inc.
Sprague & Henwood Inc.

Winter Weiss Co.—"PORTA-DRILL"

DRILLS, CORE, PORTABLE

Acker Drill Co., Inc.—"ACKER PACKSACK (AIR)"

DRILLS, CRAWLER-MOUNTED

Thor Power Tool Co.

DRILLS, HIGHWALL, HORIZONTAL, AUGER

The Salem Tool Co.—"McCARTHY"

DRILLS, MASONRY

Metallurgical Products Dept., General Electric Co.—"CARBOLOY"
Pennsylvania Drilling Co., Masonry Drill Div.

DRILLS, OVERBURDEN DOWN-THE-HOLE

Reich Bros. Mfg. Co., Inc.

DRILLS, OVERBURDEN, ROTARY-PERCUSSION

Geo. E. Failing Co., Sub. of Westinghouse Air Brake Co.

DRILLS, OVERBURDEN, SIDEWALL

Chicago Pneumatic Tool Co. "CP"
Geo. E. Failing Co., Sub. of Westinghouse Air Brake Co.
Joy Mfg. Co.
Mobile Drilling Inc.
B. J. Nykerk Corp.—"HAUSHERR"
Paris Mfg. Co.
Reich Bros. Mfg. Co., Inc.
The Salem Tool Co.—"McCARTHY"

DRILLS, OVERBURDEN, TRACTOR-MOUNTED PNEUMATIC

Chicago Pneumatic Tool Co.—"TRACDRIL"
Davey Compressor Co.
Gardner-Denver Company
Joy Mfg. Co. — "CHALLENGER"
B. J. Nykerk Corp.—"HAUSHERR"
Schramm, Inc.—"ROTADRILL ON PNEUMATRACTOR"
Winter-Weiss Co. — "PORTA-DRILL"

DRILLS, OVERBURDEN, VERTICAL AUGER

The Salem Tool Co.—"McCARTHY"

DRILLS, OVERBURDEN, VERTICAL CHURN

Bucyrus-Erie Co.
Stardrill-Keystone Co.—"SPEED STAR," "KEYSTONE"

DRILLS, OVERBURDEN, VERTICAL ROTARY

Bucyrus-Erie Co.
Cardox Corp.
Davey Compressor Co.
Geo. E. Failing Co., Sub. of Westinghouse Air Brake Co.
Joy Mfg. Co.—"CHAMPION"
Mobile Drilling Inc.
B. J. Nykerk Corp.—"HAUSHERR"
Reich Bros. Mfg. Co., Inc.
The Salem Tool Co.—"McCARTHY"
Schramm, Inc.—"ROTADRILL TRUCK MOUNTED"
Stardrill-Keystone Co.—"KEYSTONE," "FRANKS"
Winter-Weiss Co. — "PORTA-DRILL"

DRILLS, PNEUMATIC

Acme Machinery Co.
Chicago Pneumatic Tool Co.—"CP"
Davey Compressor Co.
Gardner-Denver Company
Ingersoll-Rand Co.—"VACU-JET"
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
B. J. Nykerk Corp.—"HAUSHERR"
Schramm, Inc.
Schroeder Brothers Corp.
Thor Power Tool Co.

DRILLS, PORTABLE ELECTRIC

Black & Decker Mfg. Co.

DRILLS, PROSPECTING

Hossfeld Mfg. Co. — "HOSSFELD DIRECT DRIVE"
Mobile Drilling Inc.
Reich Bros. Mfg. Co., Inc.

DRILLS, POWER-TAKE-OFF OPERATED

Mobile Drilling Inc.

DRILLS, ROCK

M. Glosser & Sons, Inc.

DRILLS, ROCK, ELECTRIC, PORTABLE

Homelite, Div. Textron Inc.—"HOMELITE-(BOSCH)"

DRILLS, ROOF-BOLTING

Acme Machinery Co.
Chicago Pneumatic Tool Co.—"CP"
Dooley Brothers
J. H. Fletcher & Co.
Gardner-Denver Company
Goodman Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Penn Machine Co.
Schroeder Brothers Corp.
Thor Power Tool Co.

DRILLS, ROTARY, PERCUSSIVE

B. J. Nykerk Corp.—"HAUSHERR"

DRILLS, SHOCK

Acker Drill Co. Inc.

DRILLS, STRIP-COAL, TRACTOR-MOUNTED PNEUMATIC

Cardox Corp.
Chicago Pneumatic Tool Co.—"H-BOOM"
Gardner-Denver Company
Joy Mfg. Co. — "CHALLENGER"
B. J. Nykerk Corp.—"HAUSHERR"
The Salem Tool Co.—"McCARTHY"
Schramm, Inc.—"ROTADRILL on PNEUMATRACTOR"

DRILLS, STRIP-COAL, VERTICAL ELECTRIC

Cardox Corp.
Penn Machine Co.
The Salem Tool Co.—"McCARTHY"

DRILLS, WAGON

Schroeder Brothers Corp.
Thor Power Tool Co.

DRIVES, ADJUSTABLE SPEED

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"VARI-PITCH"
American Blower, Div. of American-Standard
The American Pulley Co.
Electric Machinery Mfg. Co.—"AMPLI-SPEED"
General Electric Co., Apparatus Sales Div.
Link-Belt Co., Dept. CAMGL-58—"P. I. V."
Reliance Electric & Eng. Co.—"RELIANCE V—S"
Vickers Incorporated
Worthington Corp.

DRIVES, BELT

Morse Chain Co., A Borg-Warner Industry.—"HY-VO"

DRIVES, CHAIN

Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Diamond Chain Co., Inc.
Dodge Mfg. Corp.
The Four Wheel Drive Auto Co.
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "LXS," "RIVETLESS"
Morse Chain Co., A Borg Warner Industry.
National Supply Company — "NATIONAL"
Whitney Chain Co.

DRIVES, CONVEYOR

Barber-Greene Co.

DRIVES, FLUID

American Blower, Div. of American-Standard
Dodge Mfg. Corp. — "FLEXIDYNE"
Link-Belt Co., Dept CAMGL-58—"ELECTROFLUID"
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Twin Disc Clutch Co.

DRIVES, GEAR

The Louis Allis Co.
Baughman Mfg. Co., Inc.
Blaw-Knox Co.
J. D. Christian Engineers
Falk Corp.
Farrel-Birmingham Co., Inc.
Foote Brothers Gear & Machinery Co. — "GEARMOTOR," "LINE-O-MOTOR"
The Four Wheel Drive Auto Co.
Hewitt-Robins Incorporated — "JONES"
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "PARALLEL," "INLINE HELICAL," "WORM"
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Pittsburgh Gear Co.
Reliance Elec. & Eng. Co.
U. S. Electrical Motors, Inc.—"SYNCRO-GEAR"

DRIVES, ROLLER CHAIN

Morse Chain Co., A Borg-Warner Industry—"TIMANG"

DRIVES, SELECTIVE-SPEED

Link-Belt Co., Dept. CAMGL-58

DRIVES, SHAFT—MOUNTED

Falk Corp.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT"

DRIVES, SILENT CHAIN

Morse Chain Co., A Borg-Warner Industry

DRIVES, V-BELT

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"TEXROPE"
The American Pulley Co.
Bonded Scale & Machine Co.
J. D. Christian Engineers
Dayton Rubber Co.
Dodge Mfg. Corp.
Flood City Brass & Electric Co.
The Gates Rubber Co. Sales Div., Inc.
B. F. Goodrich Industrial Products Co.
Guyan Machy. Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (W. Va.)
Industrial Rubber Products Co. (Pa.)
Iowa Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Ore Reclamation Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.—"POLY-V"
Stephens-Adamson Mfg. Co.
Thermoid Co.
Worthington Corp.

DRIVES, VARIABLE-SPEED

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"VARI-PITCH"
The Louis Allis Co.
The American Pulley Co.
Bonded Scale & Machine Co.
J. D. Christian Engineers
Clark Controller Co.
Cleveland Worm & Gear Co.—"VARIATOR"
Dodge Mfg. Corp.
Dynamatic Div., Eaton Mfg. Co.—"AJUSTO-SPEDE," "DYNASPEDE"
Foote Brothers Gear & Machinery Corp.—"VARI-MOUNT"
General Electric Co., Apparatus Sales Div.
Hewitt-Robins Incorporated
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"P. I. V."
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Reeves Pulley Co. Div., The Reliance Electric & Engineering Co.—"VARI-SPEED"
Reliance Electric & Eng. Co.—"RELIANCE V—S"
Schroeder Brothers Corp.
Sterling Electric Motors, Inc.—"STERLING SPEED-TROL"
U.S. Electrical Motors, Inc.—"VARI-DRIVE"
Vickers Incorporated
Worthington Corp.

DRIVES, VARIABLE-SPEED, HYDRAULIC

American Engineering Co.—"HELE-SHAW"
Link-Belt Co., Dept. CAMGL-58

DRIVES, VARIABLE-SPEED EDDY-CURRENT

The Louis Allis Co.
Dynamatic Div., Eaton Mfg. Co.—"AJUSTO-SPEDE," "DYNASPEDE"
Hewitt-Robins Incorporated
Kanawha Mfg. Co.

DRIVES, WORM-GEAR

Cleveland Worm & Gear Co.—"CLEVELAND"
Ling-Belt Co., Dept. CAMGL-58

DUCKBILL LOADING HEADS

Goodman Mfg. Co.

DUCKBILL LOADING HEADS, REBUILT

Leman Machine Co.

DUCT, AIR

Armco Drainage & Metal Prod., Inc.
Flexaust Co.—"FLEXAUST"
Kanawha Mfg. Co.
McNally-Pittsburg Mfg. Corp.

DUCT, BUS, ELECTRICAL

I-T-E Circuit Breaker Co.
National Electric Products Co.
Revere Copper & Brass, Inc.
Westinghouse Electric Corp.

DUCT, CABLE, ELECTRICAL

Flexaust Co.—"PLICA"
National Electric Products Co.

DUMPS, CROSSOVER, KICKBACK

C. S. Card Iron Works
The Nolan Co.

DUMPS, ROTARY, AUTOMATIC

The Nolan Co.


Half Century
Rugged, Dependable
A·M·D·CO·
profit-paying Equipment
Install "Canton" American Mine Door Products in your Mine. Pay us out of increased profits.
Canton Mine Door
The Automatic Door operates mechanically by weight of car on activating levers. Air power operation may be had where desirable. Operates at any trip speed. Two doors provide air lock.
Canton Car Transfers
No alterations to track. Quickly installed and relocated—less rib to shoot than for jump switch—no hazards of cherry picker. Anti-friction bearings for easy hand operation. Manual or compressed air models available. (Air model illustrated.)
Track Switch Throwers
Electric or air operated. Route selections made by motorman at full trip speeds. Eliminates accident potential and extra men. Also ideal as Derailer.
Wet or Dry Dusting
"Canton" Little Chief goes anywhere . . . rubber tire model 22½" high; skid model 18½" high for shuttle buggies, belts or mine cars; track-mounted for haulage roads. Delivers 34 to 60 lbs. dust per minute through 50 to 400 ft. 1¼" hose.
Dustmaster
The Track Mounted Hi-Pressure "Dustmaster" is the most powerful Duster ever built. Distributes dust to back areas 500 ft. from haulway.
Canton Track Cleaners
Hydraulic controls throughout clean entire track area mechanically in one pass—no costly hand labor; no dozers or loaders required. Now operating economically in coal, iron, copper, lead, potash, and salt mines.
Mighty Midget
Weighs only 280 lbs. Easily moved on shuttle car. Hand cart available. Ideal for small mines . . . inexpensive . . . capacity 7 tons per shift
Canton Cable Splicer
"Canton" Cable Splicers reduce down time in splicing cable. Machine men should carry a pocket ful. Just pound around cable and go on working. No special tools
Canton Vulcanizer
Restores insulation to original condition. Used with Canton Splicers, strong as original cable.
The American Mine Door Company
2057 Dueber Ave., Canton 6, Ohio
Half Century of Dependable Service
Write for complete brochures.
Please use street and zone numbers.

DUMPS, ROTARY, MINE-CAR
C. S. Card Iron Works
Connellsville Mfg. & Mine Supply Co.
Heyl & Patterson, Inc.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
The Nolan Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

DUST BAGS, CLOTH
Albany Felt Co.

DUST-COLLECTION, HANDLING
Fluor Products Co.

DUST COLLECTORS, FILTER
The W. W. Sly Mfg. Co.—"SLY DYNACLONE," "SLY"

DUST COLLECTOR TUBES
Bemis Bro. Bag Co.

DUST COLLECTORS, MECHANICAL
Fly Ash Arrestor Corp.

DUST COLLECTORS, MECHANICAL, COAL HANDLING, PREPARATION
American Air Filter Co. Inc.
American Blower, Div. of American-Standards
Buttner Works, Inc.
The Ducon Co., Inc.
Fly Ash Arrestor Corp.
Joy Mfg. Co.—"JOY-MICRODYNE"
Kanawha Mfg. Co.
Kennedy Van Saun Mfg. & Engrg. Corp.
Koppers Co., Inc., Metal Products Div.
Maiac, Inc., Sub. of Blackstone Corp.
McNally-Pittsburg Mfg. Corp.
Pangborn Corp.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Schroeder Brothers Corp.
Western Precipitation Corp.—"MULTICLONE"
Wheelabrator Corp. — "DUSTUBE"

DUST COLLECTORS, MINE & DRILL
Acme Machinery Co.
American Air Filter Co. Inc.
The Ducon Co., Inc.
J. H. Fletcher & Co.
Mine Safety Appliances Co.—"DRILDUST BUCKET"

DUST COLLECTORS, VACUUM
Acme Machinery Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

DUST COLLECTORS, WET TYPE
Wheelabrator Corp.

DUST CONTROL SYSTEMS
Johnson-March Corp.—"CHEM-JET"
The W. W. Sly Mfg. Co.

DUST COUNTS
Commercial Testing & Engineering Co.

DUST-EXCLUDER BOOTS
United States Rubber Co.—"MULTIFLEX"

DUST SEAL CURTAINS
United States Rubber Co.

DUSTPROOFING EQUIPMENT, HOT OIL
Viking Machinery Sales Corp.—"VIKING"

DUSTPROOFING EQUIPMENT, LIQUID COMPOUNDS
Johnson-March Corp.

DUST SAMPLERS
Fisher Scientific Co.
Mine Safety Appliances Co.—"MIDGET IMPINGERS"

ELBOWS, RUBBER LINED
Raybestos Manhattan, Inc., Manhattan Rubber Div.
United States Rubber Co.—"USCOLITE PLASTIC"

ELECTRICAL CONTACTS, CARBON, PRECIOUS METALS
Stackpole Carbon Co.

ELECTRONIC WEIGHING SYSTEMS
Taller & Cooper, a Sub of American Electronics, Inc.

ELEVATOR BELTING
B. F. Goodrich Industrial Products Co.

ELEVATORS, BELT
Baughman Mfg. Co., Inc.
Bonded Scale & Machine Co.
Boston Woven Hose & Rubber Co.
Continental Gin Co., Ind. Div.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works, Inc.
E. F. Marsh Engrg. Co.—"MARCO"
Meckum Engrg. Co.
Ore Reclamation Co.
K. Prins & Associates
Republic Rubber Div., Lee Rubber & Tire Co.
W. J. Savage Co.
Smith Engineering Works
Stephens-Adamson Mfg. Co.
Sturtevant Mill Co.
Transall, Inc.
United States Rubber Co.

ELEVATORS, BUCKET
Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA AUSTIN-WESTERN"
Baughman Mfg. Co., Inc.
Bonded Scale & Machine Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Fairmont Machinery Co.
Gruendler Crusher & Pulverizer Co.
Hewitt-Robins Incorporated
Heyl & Patterson, Inc.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works, Inc.
E. F. Marsh Engrg. Co.—"MARCO"
McNally-Pittsburg Mfg. Corp.
Meckum Engrg. Co.
Morse Bros. Machinery Co.
Ore Reclamation Co.
K. Prins & Associates
Remaly Mfg. Co. Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Sprout, Waldron & Co., Inc.
Stephens-Adamson Mfg. Co.
Sturtevant Mill Co.
Transall, Inc.
Universal Road Machinery Co. —"RELIANCE"
Wilmot Engineering Co.

ELEVATORS, MEN & SUPPLIES

Mayo Tunnel & Mine Equipment

ELEVATORS, MINE-TRANSFER, CAR-LOADING

—See Conveyors, Elevating

ENGINE FUELS, DIESEL

Standard Oil Co. (Ind.)

ENGINE-GENERATOR SETS

Allis-Chalmers Mfg. Co., Engine-Material Handling Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Marc, Inc.
Caterpillar Tractor Co.
Chicago Pneumatic Tool Co.
Cummins Engine Co., Inc.
Detroit Diesel Engine Div., General Motors Corp.
Diesel Energy Corp.
Harnischfeger Corp.
Homelite, Div. Textron, Inc.—"HOMELITE"
The Lincoln Electric Co.—"WELDANPOWER"
Morse Bros. Machinery Co.
Murphy Diesel Co.
Nordberg Mfg. Co.—"POWER CHIEF"
R. H. Sheppard Co., Inc.
Thor Power Tool Co.
Waukesha Motor Co.—"ENGINATORS"
White Diesel Engine Div., The White Motor Co.—"WHITE SUPERIOR"
Worthington Corp.

ENGINE OILS, DIESEL

The American Oil Co.
Cities Service Oil Co.
D-A Lubricant Co., Inc.—"D-A"
Esso Standard Oil Co.—"ESSO-LUBE HD" "ESTOR HD"
Gulf Oil Corp.
Shell Oil Co.
Socony Mobil Oil Co. Inc.
Sun Oil Co.—"DYNAVIS," "SOLNUS," "SUNVIS"
Swan-Finch Petrochemicals

ENGINEERS, BLASTING VIBRATION

Vibration Measurement Engineers, Inc.

ENGINEERS, COAL PLANTS & FACILITIES

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The Daniels Co. Contractors, Inc.
Nelson L. Davis Co.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works, Inc.
K. Prins & Associates
Robinson & Robinson
Stephens-Adamson Mfg. Co.

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Cement Gun Co.—"GUNITE"®
Hewitt-Robins, Incorporated
Link-Belt Co., Dept. CAMGL-58
John F. Meissner Engineers, Inc.
Paul Weir Co., Inc.

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Blaw-Knox Co.
The Daniels Co. Contractors, Inc.
Nelson L. Davis Co.
The Four Wheel Drive Auto Co.
Heyl & Patterson, Inc.
Link-Belt Co., Dept. CAMGL-58
Peter F. Loftus Corp.
McNally-Pittsburg Mfg. Corp.
Meckum Engr. Co.
John F. Meissner Engineers, Inc.
Pierce Management, Inc.
K. Prins & Associates
Read, Davis
Robinson & Robinson
Stephens-Adamson Mfg. Co.
Templeton-Mathews Corp.
Paul Weir Co., Inc.
Western Machinery Co. — "WKE"

ENGINEERS, CONSULTING, ELECTRICAL

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General Nuclear Corp.
Herbert S. Littlewood
Peter F. Loftus Corp.
John F. Meissner Engineers, Inc.
National Electric Coil Co.
Robinson & Robinson

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Denver Equipment Co. — "DENVER"

ENGINEERS, CONSULTING, GEOLOGY

Mobile Drilling Inc.
Pennsylvania Drilling Co.
Pierce Management, Inc.
Robinson & Robinson
Paul Weir Co., Inc.
J. W. Woomer & Associates

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Lippmann Engineering Works, Inc.
Peter F. Loftus Corp.
John F. Meissner Engineers, Inc.
Robinson & Robinson
Stephens-Adamson Mfg. Co.
Paul Weir Co., Inc.

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General Nuclear Corp.
Link-Belt Co., Dept. CAMGL-58

ENGINEERS, CONSULTING, MINING

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Allen & Garcia Co.
Baton & Co., Geo. S.
Cowin & Co., Inc.
Eavenson, Auchmuty & Greenwald
Fetterman Engineering Co.
Herold Mfg. Co.
Kirk & Cowin, Inc.
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Peter F. Loftus Corp.
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Robinson & Robinson
Paul Weir Co., Inc.
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The Daniels Co. Contractors, Inc.—"DMS"
Nelson L. Davis Co.
Eavenson, Auchmuty & Greenwald
Fairmount Machinery Co.
Fuel Process Co.
Heyl & Patterson, Inc.
Industrial Engrg. & Construction Co., Inc.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Pierce Management Inc.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Robinson & Robinson
Templeton-Matthews Corp.
Paul Weir Co., Inc.

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ENGINEERS, CONSULTING, STRIPPING

Baton & Co., Geo. S.
Eavenson, Auchmuty & Greenwald
Fetterman Engineering Co.
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ENGINEERS, MINE MANAGEMENT

Pierce Management Inc.

ENGINES, BUTANE

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ENGINES, DIESEL

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Engine Material Handling Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Marc, Inc. (6 to 14 hp)
Caterpillar Tractor Co.
Chicago Pneumatic Tool Co.
Compton, Inc.
Continental Motors Corp.
Cummins Engine Co., Inc.—"CUMMINS TURBODIESEL"
Detroit Diesel Engine Div., General Motors Corp.
Diesel Energy Corp.
Harnischfeger Corp.
Hercules Motor Corp.
International Harvester Co., Construction Equipment Div.
Murphy Diesel Co.
Nordberg Mfg. Co.
The Oliver Corp.
Page Engineering Co.
R. H. Sheppard Co., Inc.
Waukesha Motor Co.
White Diesel Engine Div., The White Motor Co.—"WHITE SUPERIOR"
Worthington Corp.

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Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Continental Motors Corp.
Detroit Diesel Engine Div., General Motors Corp.
Hercules Motor Corp.
Mack Trucks, Inc.
Waukesha Motor Co.

ENGINES, DIESEL, MINE-LOCOMOTIVE

Hercules Motor Corp.

ENGINES, DUAL-FUEL

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Chicago Pneumatic Tool Co.
International Harvester Co., Construction Equipment Div.
Murphy Diesel Co.
Nordberg Mfg. Co.—"DUA-FUEL"
White Diesel Engine Div., The White Motor Co.—"WHITE SUPERIOR"
Worthington Corp.

ENGINES, DUAL-FUEL, AIR COOLED

Wisconsin Motor Corp.

ENGINES, GASOLINE

Allis-Chalmers Mfg. Co., Engine-Material Handling Div.
Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Cities Service Oil Co.
Continental Motors Corp.
Ford Div. of Ford Motor Co.
Hercules Motor Corp.
International Harvester Co., Construction Equipment Div.
The Oliver Corp.
Reo Div., The White Motor Co.
Waukesha Motor Co.

ENGINES, GASOLINE, AIR COOLED

Hercules Motor Corp.
Wisconsin Motor Corp.

ENGINES, GASOLINE AUTOMOTIVE

Allis-Chalmers Mfg. Co., Engine-Material Handling Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Continental Motors Corp.
Ford Div. of Ford Motor Co.
Hercules Motor Corp.
International Harvester Co., Construction Equipment Div.
Mack Trucks, Inc.
Waukesha Motor Co.

ENGINES, NATURAL GAS

Allis-Chalmers Mfg. Co., Engine-Material Handling Div.

ENGINES, UNATTENDED, SAFETY PANELS

Stewart Warner Corp., Alemite Div.

ENGINES, OIL

Allis-Chalmers Mfg. Co., Engine-Material Handling Div.
Cities Service Oil Co.
Continental Motors Corp.
Hercules Motor Corp.
Nordberg Mfg. Co.
White Diesel Engine Div., The White Motor Co.—"WHITE SUPERIOR"
Worthington Corp.

ETCHERS, ELECTRIC

Martindale Electric Co.

EXCAVATORS, MINING

Harnischfeger Corp.

EXHAUST OR FUME STACKS

Neff and Fry Co.

EXHAUST GAS CONDITIONERS

National Mine Service Co.

EXHAUSTERS

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Buffalo Forge Co.
Kennedy-Van Saun Mfg. & Eng. Corp.
McNally-Pittsburg Mfg. Corp.
Morse Bros. Machinery Co.
Robinson Ventilating Co.
Roots-Connersville Blower Div., Dresser Industries, Inc.

EXPLORATION EQUIPMENT

Mobile Drilling Inc.

EXPLORATION SERVICE, GEOPHYSICAL GROUTING

Mobile Drilling Inc.

EXPLOSIVES — See also Coal Breakers; Blasting Agents; Explosives, Liquid Oxygen Type

EXPLOSIVES, COAL

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AMERICAN," "BLACK DIAMOND"
Atlas Powder Co.—"COALITE," "GELCOALITE"
Austin Powder Co.
E. I. du Pont de Nemours &

Over-the-edge-dump

Operator of LeTourneau-Westinghouse Rear-Dump can dump accurately and safely over edge of hopper or spoil pile because of machine's front-wheel drive, independent braking, and electric-controlled bowl. To dump, operator backs close to edge, sets brakes on rear wheels, leaving front wheels unbraked. He then flicks switch to instantly activate electric bowl-hoist motor. As bowl rises, it pulls prime-mover back, shortening wheelbase. Bowl swings deep behind rear wheels, stops roll-back of material . . . casts it out and away. Drive wheels of prime-mover always stay on firm footing, for fast getaway in case bank begins to cave in.

COMPARE

- **capabilities of your present haulers**
- **advantages of L-W Rear-Dumps**

Hauls through soft, slippery areas ▶

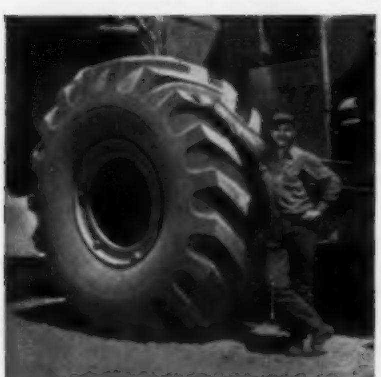
L-W Rear-Dumps haul safely through areas where other units bog down. Here's why: (1) Exclusive power-transfer differential, automatically transfers power from a slipping drive wheel to wheel on better footing. (2) 90° kingpin electric steer . . . independent of drive train . . . helps you "duck walk" out of trouble. Operator just turns prime-mover left, right, left, etc., to swing drive wheels ahead until they "walk" out and reach solid footing. (3) Rear-Dump can be "humped" forward, when bowl is empty, to get out of soft areas. Bowl is raised with front brakes locked and rear brakes released, shortening wheelbase . . . then bowl is lowered with rear brakes held and front released. Thus, without use of drive wheels, Rear-Dump "humps" forward.

No-drag "skid bottom" construction ▶

There are no springs, hangers, tie-rods cluttering up the bottom of your L-W Rear-Dump. Simple "skid bottom" construction eliminates drag over dirt and rocks. Bowl is hitched to prime-mover through a horizontal yoke extending back from kingpin, and pivoted to body itself . . . just above and ahead of rear wheels. There is no frame or sub-frame to get out of alignment. Front-wheel drive and kingpin steer eliminate long drive shaft, hinged steering connections.

Big target for fast, easy loading

L-W Rear-Dumps' big, wide, unobstructed top makes an easy target for your shovel operators. Low, wide rear entry of this hauler lets dipper swing in smoothly, quickly . . . in one continuous arc . . . rather than the up-over-in, up-over-out motions needed with high-top trucks. ▶



◀ **Big, single tires absorb shock, eliminate trouble of duals**

4 giant, low-pressure tires dissipate vibrations and stress of high-speed hauls . . . absorb shock of heavy loads dropped into bowl. They flex and roll easily over rocks that might bruise or break smaller duals. There is no divided face where wedged-in rock fragments can wear and tear.

Write or phone your local L-W Distributor for more information on these big-production, low-cost Rear-Dumps. They are available in 11, 22, and 35-ton sizes.

R-1871-MQ-1

LeTOURNEAU-WESTINGHOUSE COMPANY, PEORIA, ILLINOIS

A Subsidiary of Westinghouse Air Brake Company

Where quality is a habit

Can ONE tractor keep up with your

Co., Inc., Explosives Div.—"GELOBEL," "DUOBEL," "MONOBEL," "LUMP-COAL"
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Olin-Mathieson Chemical Corp., Explosives Div.

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Olin Mathieson Chemical Corp., Explosives Div.

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Visking Co., Plastics Div. — "VIS QUEEN"

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Atlas Powder Co.—"APEX," "AMODYN," "GIANT GELATIN"
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div. — "RED CROSS," "EXTRA," "GELEX"
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Olin-Mathieson Chemical Corp., Explosives Div.

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American Optical Co., Safety Products Div.
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Galigher Co.
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Leman Machine Co.
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Meckum Engr. Co.
Ore Reclamation Co.
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Simplicity Engineering Co.
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Robert Holmes & Bros., Inc.
Industrial Engrg. & Construction Co., Inc.
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Marietta Mfg. Co.
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Diehl Manufacturing Co.

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E. K. Campbell Co.—"EKCCO"
Chelsea Fan and Blower Co., Inc.
Clarage Fan Co.
Coppus Engineering Corp. — "VANO," "VENTAIR"
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Emglo Products Corp. — "EMGLO"
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M. Glosser & Sons Inc.
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Jeffrey Mfg. Co. — "AERO-DYNE"
Joy Mfg. Co.—"AXIVANE"
Robbins & Myers, Inc. — "PROPELLAIR"
Robinson Ventilating Co.
Westinghouse Electric Corp.
Westinghouse Electric Corp., B. F. Sturtevant Div.—"SILENT-VANE," "AXIFLO," "TUR-BOVANE"
L. J. Wing Mfg. Co. Div. of Aero Supply Mfg. Co. Inc—"WING-FOIL"

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Deister Machine Co.
Heyl & Patterson, Inc.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

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Bonded Scale & Machine Co.
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J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Diamond Iron Works, Div. Goodman Mfg. Co.
Fairmont Machinery Co.
Gruendler Crusher & Pulverizer Co.
Helmick Foundry-Machine Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Kennedy-Van Saun Mfg. & Eng. Corp.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works
McNally-Pittsburg Mfg. Corp.
Meckum Engr. Co.
Morse Bros. Machinery Co.
Pioneer Engineering, Div. of Poor & Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Smith Engineering Works
Stephens-Adamson Mfg. Co. — "AMSCO"
Straub Mfg. Co., Inc.
Traylor Engineering & Mfg. Co.
Universal Engineering Corp. — "WOBBLER"
Webster Mfg., Inc.
Williams Patent Crusher & Pulv. Co.

FEEDER-RETARDERS, MINE CAR

Link-Belt Co., Dept. CAMGL-58
The Nolan Co.

FEEDERS, BELT

ABCs® Scale Div., McDowell Co., Inc.
B-I-F Industries, Inc.—"HI-WEIGH."
Barber-Greene Co.
Bonded Scale & Machine Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Denver Equipment Co.—"AD-JUSTABLE STROKE"
Fairmont Machinery Co.
Gruendler Crusher & Pulverizer Co.
Hardinge Co., Inc.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Industrial Physics & Electronics Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Kennedy-Van Saun Mfg. & Eng. Corp.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works
E. F. Marsh Engrg. Co.—"MARCO"
Meckum Engr. Co.
Morse Bros. Machinery Co.
Ore Reclamation Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.
Transall, Inc.
Universal Road Machinery Co. —"RELIANCE"
Webster Mfg., Inc.
Williams Patent Crusher & Pulv. Co.

FEEDERS, CHAIN

Link-Belt Co., Dept. CAMGL-58
Ross Screen & Feeder Co.—"ROSS"

FEEDERS, CHLORIDE, LIME, REAGENT, SALT, ETC.

B-I-F Industries, Inc.—"HI-WEIGH," "ROTODIP," "ADJUST-O-FEEDER," "CHEM-O-FEEDER," "PROPORTIONEER"
Denver Equipment Co.—"DEN-VER"
Fischer & Porter Co.
Galigher Co.—"GEARY"
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Manzel Div., Houdaille Industries, Inc.
Morse Bros. Machinery Co.
The Permutit Co., a div. of Pfaudler Permutit Inc.
W. J. Savage Co.—"SAVAGE-GAUNTT"
Schaffer Poidometer Co.
Syntron Co.

FEEDERS, CONTINUOUS-WEIGHING

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Hardinge Co., Inc.—"CON-STANT WEIGHT"
Industrial Physics & Electronics Co.
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Merrick Scale Mfg. Co.—"FEEDOWEIGHT"
Schaffer Poidometer Co.
Syntron Co.

FEEDERS, GRIZZLY

Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Nordberg Mfg. Co.

FEEDERS, MANGANESE

Continental Gin Co., Ind. Div.
Link-Belt Co., Dept. CAMGL-58

FEEDERS, MINE-CAR

Connellsville Mfg. & Mine Supply Co.
Fairmont Machinery Co.
Link Belt Co., Dept. CAMGL-58
The Nolan Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Sanford Day Iron Works, Inc.
Schroeder Brothers Corp.
Stephens-Adamson Mfg. Co.

FEEDERS, OSCILLATING

Link Belt Co., Dept. CAMGL-58

FEEDERS, PLATE

Diamond Iron Works, Div. Goodman Mfg. Co.

FEEDERS, RECIPROCATING

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Baldwin-Lima-Hamilton Corp., Construction Equipment Div. —"LIMA AUSTIN-WEST-ERN"
Barber-Greene Co.
Bonded Scale & Machine Co.—"BONDED"
Chain Belt Co.—"REX"
Diamond Iron Works, Div. Goodman Mfg. Co.
Fairmont Machinery Co.
Gruendler Crusher & Pulverizer Co.

Hewitt-Robins Incorporated
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works
McLanahan & Stone Corp.
McNally-Pittsburg Mfg. Corp.
E. F. Marsh Engrg. Co.—"MARCO"
Ore Reclamation Co.
Pioneer Engineering, Div. of Poor & Co.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Smith Engineering Works
Stephens-Adamson Mfg. Co.
Straub Mfg. Co., Inc.
Transall, Inc.
Universal Road Machinery Co.—"RELIANCE"
Webster Mfg., Inc.
Wilmot Engineering Co.

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Link-Belt Co., Dept. CAMGL-58

FEEDERS, ROTARY TABLE

Link-Belt Co., Dept. CAMGL-58

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Cleveland Vibrator Co.
Eriez Mfg. Co.
Gruendler Crusher & Pulverizer Co.
Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
National Air Vibrator Co.
Simplicity Engineering Co.—"OS-A-VEYOR"
Stephens-Adamson Mfg. Co.
Syntron Co.—"VIBRA-FLOW"

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ABCs® Scale Div., McDowell Co., Inc.

FENCE, FIELD

American Steel & Wire Div., U. S. Steel Corp.—"AMERICAN"

FENCING, CHAIN, LINK

Page Steel & Wire Div., American Chain & Cable Co. Inc.

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Bethlehem Steel Co.
Colorado Fuel & Iron Corp.—"REALOCK," "CF&I"

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C. R. Daniels Co.
Eimco Corp.
Filter Fabrics, Inc.
Fisher Scientific Co.
Johns-Manville—"CELITE"
Koppers Co., Inc., Metal Products Div.
Mine Safety Appliances Co.
National Filter Media Corp.
Newark Wire Cloth Co.—"METALLIC"
Peterson Filters & Engineering Co.
Riegel Textile Corp.—"RIEGEL"

FILTER CLOTH, METALLIC

W. S. Tyler Co.

FILTER CLOTH, WOVEN-WIRE

Cleveland Wire Cloth & Mfg. Co.

FILTER MEDIA, AIR

Filter Fabrics, Inc.

FILTERS, AIR

American Air Filter Co., Inc.
A. W. Cash Valve Mfg. Corp.
Coppus Engineering Corp.
The Ducon Co., Inc.
Goodyear Tire & Rubber Co.—"PLIOTRON"
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.—"FULFLO"
Mine Safety Appliances Co.
New Jersey Meter Co.—"DRI-AIR"
Western Precipitation Corp.—"DUALAIRE"
Wheelabrator Corp.

FILTERS, CENTRIFUGAL, SOLIDS-LIQUID

Colorado Iron Works Co., A Sub. of Mine Smelter & Supply Co.

FILTERS, DISC, DRUM, VACUUM

Bird Machine Co.—"BIRD-YOUNG"
Denver Equipment Co.—"DENVER"
Dorr-Oliver, Inc.
Eimco Corp.
Koppers Co., Inc., Metal Products Div.—"AERO TURN"
Morse Bros. Machinery Co.
Peterson Filters & Engineering Co.—"TPA DISC," "TFR DRUM"

FILTERS, ELECTRIC INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section—"PERMAFIL"

FILTERS, FUEL, HYDRAULIC & LUBE OILS, PORTABLE & LINE

Schroeder Brothers Corp.

FILTERS, FUEL, HYDRAULIC & LUBE OILS

A. W. Cash Valve Mfg. Corp.
Compton, Inc.
Dorr-Oliver, Inc.
The Duriron Co., Inc.
United States Rubber Co.—

"A.C. OIL"

FILTERS, HORIZONTAL

Bird Machine Co.—"BIRD-PRAYON"
Dorr-Oliver, Inc.
The Duriron Co., Inc.
Eimco Corp.

FILTERS, MAGNETIC

Magnetic Engrg. & Mfg. Co.

FILTERS, OIL

Infilco Inc.—"IMPINGO"

FILTERS, PRESSURE

S. P. Kinney Engineers, Inc.

FILTERS, WATER

Bird Machine Co.
A. W. Cash Valve Mfg. Corp.
Dorr-Oliver, Inc.
The Duriron Co., Inc.
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FIRE ALARMS

Walter Kidde & Co., Inc. — "KIDDE ATMO"
United States Rubber Co.

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American LaFrance Corp.—"AMERICAN LA FRANCE"
Ansul Chemical Co. — "ANSUL"
The Four Wheel Drive Auto Co.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Mine Safety Appliances Co.

FIRE BRICK

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FIRE EXTINGUISHERS

American LaFrance Corp.—"AMERICAN LA FRANCE"
Fyr-Fyter Div.
Guyan Machy. Co.—"KIDDE"
Walter Kidde & Co., Inc. — "FYRE-FREEZ," "KIDDE"
National Mine Service Co.
Pulmosan Safety Equip. Co.
Swan-Finch Oil Petrochemicals —"AEROSOL"
United States Rubber Co.

FIRE EXTINGUISHERS, DRY CHEMICAL & WATER

Ansul Chemical Co.—"ANSUL"

FIRE FIGHTING EQUIMENT, HIGH PRESSURE FOG

Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.

FIRE NOZZLES

Bete Fog Nozzle, Inc.

FIRE-PROTECTION SYSTEMS

American LaFrance Corp.—

If You Use Blasting Caps

"AL FITE CO_2" "FOAM-ITE AIRFOAM"
Cardox Corp.
Fyr-Fyter Div.
Grinnell Co.
Walter Kidde & Co., Inc. — "KIDDE CARBON DIOXIDE"

FIRE PROTECTION SYSTEMS, DRY CHEMICAL

Ansul Chemical Co. — "ANSUL"

FIRST-AID EQUIPMENT

E. D. Bullard Co.
Fisher Scientific Co.
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.—"ALL-WEATHER"
National Mine Service Co.
Pulmosan Safety Equip. Co.

FITTINGS, ALUMINUM CABLE FEEDER

The Elreco Corp.

FITTINGS, CHAIN

Crosby-Laughlin Div., American Hoist & Derrick Co.—"CROSBY-LAUGHLIN"

FITTINGS, GREASE

Guyan Machy. Co.—"ALEMITE"
Keystone Lubricating Co.
Ore Reclamation Co.
Stewart-Warner Corp., Alemite Div.

FITTINGS, TUBE

Weatherhead Co., Fort Wayne Div.

FITTINGS, WIRE ROPE

Crosby-Laughlin Div., American Hoist & Derrick Co.—"CROSBY-LAUGHLIN"

FLAME CUTTING MACHINES

Air Reduction Sales Co., A Div of Air Reduction Co. Inc.

FLAME SAFETY LAMPS

Mine Safety Appliances Co.—"WOLF"
National Mine Service Co.

FLANGE BLOCKS

Browning Mfg. Co.

FLANGED MOUNTINGS, ANTI-FRICTION BEARING

Link-Belt Co., Dept. CAMGL-58
SKF Industries, Inc.

FLASHLIGHTS, SAFETY & INDUSTRIAL

E. D. Bullard Co.
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.

FLEXIBLE SHAFT MACHINES, GRINDING

Martindale Electric Co.

FLIGHTS, CONVEYOR LINE

Link-Belt Co., Dept. CAMGL-58
Remaly Mfg. Co., Inc.

FLOAT & SINK TEST SOLUTIONS

American Minechem Co. "CERTIGRAV"

FLOAT & SINK TESTERS

Commercial Testing & Engineering Co.
The Daniels Co., Contractors, Inc.
Robert Holmes & Bros., Inc.
Reich Bros. Mfg. Co., Inc.—"DELATESTER"

FLOCCULATING AGENTS

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AEROFLOC®"
American Minechem Co.—"CHEMFLOC"
Denver Equipment Co.
B. F. Goodrich Chemical Co.—"GOOD-RITE K-720"
Hercules Powder Co.
Hodag Chemical Corp.

FLOODLIGHTS

Crouse-Hinds Co.
General Electric Co., Lamp Div.—"GENERAL ELECTRIC"
Homelite, Div. Textron Inc.—"HOMELITE"
National Mine Service Co.
Phoenix Metal Products, Metal Spinning Div.—"STURDILITE"
Westinghouse Electric Corp.

FLOODLIGHTS, PORTABLE

Mine Safety Appliances Co.

FLOOR PLATE

United States Steel Corp.—"USS MULTIGRIP"

FLOOR RESURFACES

Stonhard Co. Inc.—"STONPACH," "STONCAP," "STONHARD RESURFACER"

FLOORING, OPEN STEEL

Blaw-Knox Co.

FLOORING, WOOD BLOCK

Republic Creosoting Co.

FLOTATION CONDITIONERS

American Minechem Co.
The Daniels Co., Contractors, Inc.
Denver Equipment Co.—"DENVER"
Morse Bros. Machinery Co.
Western Machinery Co.—"WEMCO FAGERGREN"

FLOTATION FROTHERS

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AERO®,"
American Minechem Co.
Denver Equipment Co.

FLOTATION LAB MACHINES

Denver Equipment Co.—"DENVER SUB-A"
Galigher Co.—"AGITAIR"
Morse Bros. Machinery Co.
Western Machinery Co.—"WEMCO FAGERGREN"

FLOTATION MACHINES

American Well Works
The Daniels Co., Contractors, Inc.
Denver Equipment Co.—"DENVER SUB-A"
Galigher Co.—"AGITAIR"
Morse Bros. Machinery Co.—"JETAIR"
Ore Reclamation Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
The Stearns-Roger Mfg. Co.
Western Machinery Co.—"WEMCO FAGERGREN"
Wilmot Engineering Co.

FLOTATION PLANTS, PORTABLE

The Daniels Co., Contractors, Inc.
Denver Equipment Co.—"DENVER SUB-A"

FLOTATION REAGENTS

American Cyanamid Co. Explosives and Mining Chemicals Dept.—"AEROFROTH®"
American Minechem Co.—"CHEMFROTH"
Denver Equipment Co.
The Dow Chemical Co.—"DOWFROTH 250"
Hercules Powder Co.
Hodag Chemical Corp.

FLOTATION TESTING LABORATORIES

Commercial Testing & Engineering Co.
Denver Equipment Co.—"DENVER"
Galigher Co.

FLOW METERS

B-I-F Industries, Inc.

FLUIDS, HYDRAULIC — See Hydraulic Fluids

FLUID POWER PUMP GENERATORS, VALVE CONTROLS, MOTOR DRIVES, CYLINDER DRIVES

The Commercial Shearing & Stamping Co.

FLUX, WELDING, SALVAGE EQUIPMENT

Robert Holmes & Bros., Inc.

FOOTMATS

Onox, Inc.

FORGINGS

American Chain Div., American Chain & Cable Co., Inc.

FORGINGS, DROP

Ladish Co.

FORGINGS, UPSET

New Departure Div., General Motors Corp.

FREEZEPROOFING CHEMICALS

American Minechem Co.
Fuel Process Co.—"FU PRO CO"
Morton Salt Co.—"FORMULA 5"
Wyandotte Chemicals Corp., Michigan Alkali Div.

FREEZEPROOFING OILS

Standard Oil Co. (Ind.)

FUEL OIL

Gulf Oil Corp.

FUELS

Pennsylvania Refining Co.

FURNACE ENCLOSURES

Bigelow-Liptak Corp.

FURNACE WALLS AND ARCHES

Geo. P. Reintjes Co.

FURNACES, ARCH AND WALL CONSTRUCTION

Bigelow-Liptak Corp.

FURNACES, HEAT DRYING

Bigelow-Liptak Corp.
Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"SKINNER"
Robert Holmes & Bros., Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

FURNACES, HEAT TREATING

Hevi-Duty Electric Co.

FURNACES, HEATING

E. K. Campbell Co.—"THERMIDAIRE"
Dallas Engineers Inc., Coal-O-Matic Div. — "ANTHRA-FLOW," "COAL-O-MATIC"

FURNACES, LABORATORY COMBUSTION

Central Scientific Co.
Fisher Scientific Co.
Hevi-Duty Electric Co.

FURNACES, METAL-MELTING

Kuhlman Electric Co.

FURNACES, PLANT-HEATING, DIRECT-FIRED WARM-AIR

E. K. Campbell Co. — "THERMIDAIRE"

FURNACES, WARM-AIR, HEAVY-DUTY

E. K. Campbell Co.—"THERMIDAIRE"

FUSE, DETONATING

Atlas Powder Co.
Austin Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
Ensign-Bickford Co. — "PRIMACORD"
Hercules Powder Co.
King Powder Co., Inc.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.

FUSE, SAFETY, BLASTING

Atlas Powder Co.
E. I. du Pont de Nemours & Co., Inc., Explosives Div.
Ensign-Bickford Co.
Hercules Powder Co.
King Powder Co., Inc.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.

FUSE BOXES, EXPLOSIONPROOF

Albert & J. M. Anderson Mfg. Co.

FUSE HOLDERS, BLASTING

National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.

FUSE HOLDERS, ELECTRICAL

Bussmann Mfg. Div., McGraw-Edison Co., — "BUSS"
Circuit Protective Devices Dept., General Electric Co.
Mosebach Electric & Supply Co.

FUSE REDUCERS, ELCTRICAL

Bussmann Mfg. Div., McGraw-Edison Co.—"BUSS"
Holub Industries, Inc.
Ideal Industries, Inc.
Trico Fuse Mfg. Co.

FUSES, ELECTRICAL

Bussmann Mfg. Div., McGraw-Edison Co.—"BUSS," "FUSETRON"
Economy Fuse & Mfg. Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
Guyan Machy. Co.—"BUSS-MAN"
Mining Machine Parts Inc.
Mosebach Electric & Supply Co.
National Mine Service Co.
Standard Devices Co.
Trico Fuse Mfg. Co.—"TRICO"
Westinghouse Electric Corp.

GAGES, LIQUID-LEVEL

The Lunkenheimer Co.—"LUNKENHEIMER"

GAGES, TRACK

The Aldon Co.
L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.
The Leetonia Tool Co.
Nordberg Mfg. Co.
H. K. Porter Co., Connors Steel Div.

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The Bristol Co.—"BRISTOLS"
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Helicoid Gage Div., American Chain & Cable Co., Inc.

GAGES, PRESSURE, VACUUM, FLOW

Minneapolis-Honeywell Regulator Co., Industrial Div.

GALVANOMETERS, BLASTING

American Cyanamid Co., Explosives and Mining Chemicals

If You Use Blasting Caps

EXAMINE THESE FEATURES

❶ DEPENDABLE FIRE—Special alloy is used as the bridge wire in the firing element of Hercules Electric Blasting Caps. Wire is noncorrosive.

❷ ENGINEERED SHELL—Bronze shell of a Hercules cap goes through fifteen separate operations while it is being expertly shaped.

❸ TOUGH, HIGH DIELECTRIC INSULATION—Leg wires of Hercules caps are coated with plastic insulation for outstanding toughness, resistance to abrasion, superior dielectric qualities.

❹ SECURELY ANCHORED—A cast sulfur plug in the upper part of shell anchors entire firing mechanism in place.

❺ WATERTIGHT WATERPROOFING—A special Hercules waterproofing formulation minimizes the possibility of moisture or dampness penetration.

❻❼ DOUBLE-PACKED WALLOP—Bridge wire extends into the priming charge and makes positive contact to give rapid ignition.

HERCULES BLASTING CAPS

Partners in Dependability with Hercules® Explosives

HERCULES POWDER COMPANY
INCORPORATED

Explosives Department: 900 Market Street, Wilmington 99, Delaware

Birmingham, Chicago, Duluth, Hazleton, Joplin, Los Angeles, New York, Pittsburgh, Salt Lake City, San Francisco

XR58-1

Dept.
Hercules Powder Co.

GAS ANALYSIS EQUIPMENT

Taller & Cooper, a Sub. of American Electronics, Inc.

GAS DETECTORS, MINE

Mine Safety Appliances Co. — "W-8 METHANE, M-6 METHANE"
National Mine Service Co.

GAS MASKS

E. D. Bullard Co.
Mine Safety Appliances Co. — "ALL-SERVICE"
Pulmosan Safety Equip. Co.

GASKETS & MATERIALS

Anchor Packing Co.
The Garlock Packing Co.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Johns-Manville—"GOETZE SPIROTALLIC"
Raybestos Manhattan, Inc., Manhattan Rubber Div.—"R/M"
United States Rubber Co.

GASKETS, RUBBER

Hewitt-Robins Incorporated

GASOLINE HAMMERS

Syntron Co.

GEAR DRESSING

Swan-Finch Petrochemicals — "AEROSOL"

GEARMOTORS

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
The Louis Allis Co.
J. D. Christian Engineers — "RITE-LO-SPEED"
Cone-Drive Gears Div., Michigan Tool Co.
Continental Gin Co., Ind. Div.
Electro Dynamic Div. of General Dynamics Corp.
Elliott Co.
Ensign Electric & Mfg. Co.
Falk Corp.—"MOTOREDUCERS ALL-MOTOR"
Foote Brothers Gear & Machinery Corp.
General Electric Co., Apparatus Sales Div.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," "GEARMOTORS," "MOTOGEARS"
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Morse Bros. Machinery Co.
Mosebach Electric & Supply Co.
Ore Reclamation Co.
Reliance Elec. & Eng. Co.
W. J. Savage Co.
Sterling Electric Motors, Inc. —"STERLING SLO-SPEED"
Transall, Inc.
Westinghouse Electric Corp.

GEARS

J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Falk Corp.—"FALK"
Farrel-Birmingham Co., Inc.
Flood City Brass & Electric Co.
Foote Brothers Gear & Machinery Corp.—"DUTI-RATED"
The Four Wheel Drive Auto Co.
Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
S. P. Kinney Engineers, Inc.
Link-Belt Co., Dept. CAMGL-58
Marathon Coal Bit Co. Inc.—"MARATHON," "TRACY"
McNally-Pittsburg Mfg. Corp.
Mosebach Electric & Supply Co.
Penn Machine Co.
Pittsburgh Gear Co.
W. J. Savage Co.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
Transall, Inc.
Vulcan Iron Works
West Virginia Armature Co.
Westinghouse Electric Corp.
Wilmot Engineering Co.

GEARS, MINE-LOCOMOTIVE, HEAT-TREATED

Penn Machine Co.

GEARS, PLASTIC

United States Rubber Co.

GEARS, REVERSE & REDUCTION

Link-Belt Co., Dept. CAMGL-58
Twin Disc Clutch Co.

GEARS, SEMI-STEEL

Link-Belt Co., Dept. CAMGL-58
McLanahan & Stone Corp.

GEARS, WORM

Cone-Drive Gears Div., Michigan Tool Co.
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58

GENERATION CONTROL

Electric Machinery Mfg. Co. — "AUTO SYNCHRONIZEN"

GENERATORS, AC

Electric Machinery Mfg. Co.—"AMP-PAK"
The Electric Products Co.

GENERATORS, AC, DC

Westinghouse Electric Corp.

GENERATORS, WATER WHEEL

Electric Machinery Mfg. Co.

GEOPHYSICAL SURVEYS, AIRBORNE

Fairchild Aerial Surveys, Inc.

GLOVES

American Optical Co., Safety Products Div.
General Scientific Equipment Co.—"GS"
Johns-Manville—"WEARBESTOS"
Mine Safety Appliances Co. —"ALL-PURPOSE"
Pulmosan Safety Equip. Co.
Riegel Textile Corp. Glove Div.—"RIEGEL WORK GLOVES"

GLOVES, RUBBER

Continental Rubber Works
Fisher Scientific Co.
General Scientific Equipment Co.—"GS"
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"KOROSEAL"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.

GLOVES, RUBBER, INDUSTRIAL

United States Rubber Co.

GOGGLE-CLEANING STATIONS

American Optical Co., Safety Products Div.
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.
United States Safety Service Co.—"SAF-I-CUP"

GOGGLES

American Optical Co., Safety Products Div.
Bausch & Lomb Optical Co.
E. D. Bullard Co.
Chicago Eye Shield Co.
Fisher Scientific Co.
General Scientific Equipment Co.—"GS"
Marathon Coal Bit Co. Inc.—"WILSON"
Martindale Electric Co.
Mine Safety Appliances Co.—"SOFTSIDES"
Pulmosan Safety Equip. Co.
United States Safety Service Co.—"SAF-I-CUP"

GOVERNORS, COMPRESSED-AIR, UNLOADING

R. Conrader Co. Inc.—"CONRADER"

GRADER BLADES

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Steel Foundries—"WEARPACT"
Caterpillar Tractor Co.
Colorado Fuel & Iron Corp.—"CF&I"
Electric Steel Foundry Co.
Galion Iron Works & Mfg. Co.

GRADERS, MOTOR

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Austin-Western, Construction Equipment Div., Baldwin-Lima-Hamilton Corp.
Caterpillar Tractor Co.
Galion Iron Works & Mfg. Co.
Huber-Warco Co.—"HUBER-WARCO"
LeTourneau-Westinghouse Co.

GRAPHITE, LUBRICATING & GREASES

The American Oil Co.
Joseph Dixon Crucible Co.
Esso Standard Oil Co.—"VAN CAZAR," "VAN ESTAN," "VAN NAKTA"
Keystone Lubricating Co.

GRATING, FLOOR, STAIR

Dravo Corp.
Hendrick Mfg. Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

GREASE-LINE EXTENSIONS AND FITTINGS

National Mine Service Co. (Clarkson Div.)—"CLARKS"

GREASES

The American Oil Co.
Bearings, Inc.
Cities Service Oil Co.
Gulf Oil Co.
Hulbert Oil & Grease Co.
Lubriplate Div., Fiske Bros. Refining Co.— "LUBRIPLATE"
The Pure Oil Co.—"POCO HYPRONOX," "POCO HT-EP," "POCO GEARSHIELD," "PURO GREASE"
Sinclair Refining Co.—"LITHOLINE"
Socony Mobil Oil Co. Inc.

GREASES, HEAT & WATER RESISTANT

Hulbert Oil & Grease Co.
Socony Mobil Oil Co. Inc.
Swan-Finch Petrochemicals

GREASES, LITHIUM BASE

Socony Mobil Oil Co. Inc.
Sun Oil Co.—"PRESTIGE"

GREASES, MINE CAR

Hulbert Oil & Grease Co.
Pennsylvania Refining Co.
Sinclair Refining Co.
Socony Mobil Oil Co. Inc.
Sun Oil Co.

GREASES, RUST-PREVENTIVE

Socony Mobil Oil Co. Inc.
Sun Oil Co.

GRINDERS, DRILL-BIT

Herold Mfg. Co.

GRINDERS, PEDESTAL, TOOL

South Bend Lathe Works

GRINDERS, PORTABLE

Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
The Cincinnati Electrical Tool Co.
Guyan Machy. Co.—"BLACK & DECKER"
Ingersoll-Rand Co.
Joseph T. Ryerson & Son, Inc.
Thor Power Tool Co.

GRINDERS, STATIONARY

The Cincinnati Electrical Tool Co.
Fisher Scientific Co.
Lippmann Engineering Works Inc.
Joseph T. Ryerson & Son, Inc.
Snap-on Tools Corp.

GRINDING WHEELS

Guyan Machy. Co.—"CARBORUNDUM"
Kennametal, Inc., Mining Tool Div.
Marathon Coal Bit Co. Inc.—"SIMONDS"
Minnesota Mining & Mfg. Co.—"PG"
Norton Co.—"ALUNDUM CRYSTOLON"
Raybestos Manhattan, Inc. Manhattan Rubber Div.—"MANHATTAN"
Joseph T. Ryerson & Son, Inc.
Snap-on Tools Corp.
United States Rubber Co.

GRINDING WHEELS, DIAMOND

Hoffman Brothers Drilling Co.
Norton Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
J. K. Smit & Sons—"SECOMET"

GRIZZLIES

American Brake Shoe Co., Amsco Div.—"AMSCO"
Diamond Iron Works, Div. Goodman Mfg. Co.
Hewitt-Robins Incorporated
Iowa Mfg. Co.
Kennedy Van Saun Mfg. & Eng. Co.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engineering Works Inc.
McNally-Pittsburg Mfg. Corp.
Nordberg Mfg. Co.—"SYMONS"
Simplicity Engineering Co.
Smith Engineering Works
Stephens-Adamson Mfg. Co.—"LIVE-ROLL"
Traylor Engineering & Mfg. Co.
W. S. Tyler Co.—"TY-ROCK," "TYLER NIAGARA"
Universal Engineering Corp.

GRIZZLIES, VIBRATING

Syntron Co.

GRIZZLY BARS

American Brake Shoe Co., Amsco Div.—"AMSCO"
American Steel Foundries—"WEARPACT"
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.—"C F & I"
Hewitt-Robins Incorporated
Kensington Steel, Div. of Poor & Co.
National Malleable & Steel Castings Co.
Nordberg Mfg. Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

GROUND CLAMPS

Albert & J. M. Anderson Mfg. Co.
Delta-Star Electric Div., H. K. Porter Co. (Delaware)
Duquesne Mine Supply Co.
Erico Products, Inc.—"CADDY"
Mosebach Electric & Supply Co.
Ohio Brass Co.
Trico Fuse Mfg. Co.—"KLIPLOK"

GROUND DETECTORS

Central Mine Supply Co. Div., Pickard Industries, Inc. —"PROTECTO"
National Mine Service Co.—"GROUND SENTINEL"

GROUND INDICATORS

Schroeder Brothers Corp.

GROUND RODS

Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"

GROUSER BARS

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Kensington Steel, Div. of Poor & Co.
Stulz-Sickles Co.—"SSHI-C"

GROUTING

Cement Gun Co.—"GUNITE"
Hoffman Brothers Drilling Co.
Mott Core Drilling Co.
Pennsylvania Drilling Co.
Sika Chemical Corp.—"INTRAPLAST"

GROUTING EQUIPMENT

Sprague & Henwood

GUARD RAIL, DEEP BEAM

L. B. Foster Co.

HACK-SAW BLADES

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Guyan Machy. Co.—"DISSTON"
Simonds Saw & Steel Co.—"RED END"
Snap-on Tools Corp.

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Acme Machinery Co.
Chicago Pneumatic Tool Co.
Gardner-Denver Company
Ingersoll-Rand Co.
Joy Mfg. Co.
Mining Progress, Inc.
B. J. Nykerk Corp.—"HAUSHERR"
Penn Machine Co.
Schroeder Brothers Corp.
Thor Power Tool Co.
Worthington Corp.

HAMMERS, ELECTRIC

Homelite, Div. Textron Inc.—"HOMELITE-(BOSCH)"

ELECTRIC

Black & Decker Mfg. Co.

HAMMERS, REPLACEABLE SOFT-FACE

Snap-on Tools Corp.

HANDLES, TOOL

The Leetonia Tool Co.
Marion Handle Mills, Inc.—"ACE, VIRGINIAN, A GRADE"
The Salem Tool Co.—"BLACK DIAMOND," "PERFECT"

HANGERS, SHAFT—See Shaft Hangers

HARDFACING FLUXES

The Lincoln Electric Co.—"H535," "H545," "H550," "H560."

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Air Reduction Sales Co., A Div. Air Reduction Co., Inc.
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American Brake Shoe Co., Amsco Div.—"AMSCO"
Ampco Metal, Inc.—"AMPCO TRODE"
Coast Metals, Inc.
Crucible Steel Co. of America, "REXWELD"
Eutectic Welding Alloys Corp.—"EUTECHROMS"
International Nickel Co., Inc.
Lincoln Electric Co.—"ABRASOWELD," "MANGANWELD," "JET-HARD BU 90," "FACEWELD," "SURFACEWELD," "STAINWELD," "TOOLWELD," "WEARWELD," "MANGJET"
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Metal & Thermit Corp.—"HARDEX"
Resisto-Loy Co., Inc.—"RESISTO-LOY, ISOROD, MANGA-TONE, NM," "CHROMO-LOY," "FLINTYPE V. H.," "TWO-TONE T. H.," "MANGA-KOTE"
The Sight Feed Generator Co.—"REXARC"
Stoody Co.—"STOODY"
Stulz-Sickles Co.—"SEACO"
Taylor-Wharton Co. Div. Harsco Co.—"TIMANG"
Wall Colmonoy Corp.—"COLMONOY"

HARDFACING SERVICE

American Alloy Corp.
Sprague & Henwood

Two 12-ton ore bridges, built, designed and installed for a large steel company.

DRAVO **HEAVY MATERIALS-HANDLING** EQUIPMENT

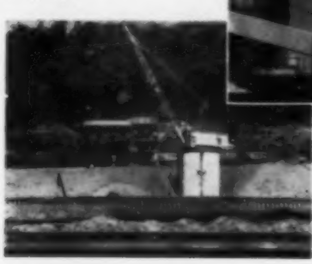
...CUSTOM BUILT FOR **YOU!**

Travelling unloading towers built to handle imported iron ore at an Atlantic port.

Whirler crane mounted on pontoon hull is used for dredging and general contract work.

Light-weight man trolley installation increased bridge handling capacity 60%.

Coal unloader designed and built for a large mid-western electric power company.



Stationary whirler crane designed and built to transfer coal from barges to hopper cars.

Over-all economical and safe performance is best obtained by using materials-handling equipment designed to suit your operating conditions. If you're planning a new materials-handling installation, we suggest an early "Round Table" session with Dravo engineers.

From actual experience over the past 60 years in building and installing the equipment shown here, valuable data is available in working out the features you want in your installation. This information, along with your own operating experience, can be used to create a design incorporating all the best features for easy maintenance, a high safety factor and simple, economical and satisfactory operation.

You can profit by taking advantage of this specialized "Round Table" service.

DRAVO

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HAULAGES, R. R. CAR BOAT
Link-Belt Co., Dept. CAMGL-58

HAULERS, FLAT-BED
LeTourneau-Westinghouse Co.

HAULING UNITS
Athey Products Corp.

HAULING UNITS, RUBBER TIRED
Athey Products Corp.

HAULS, CAR
Link-Belt Co., Dept. CAMGL-58

HEADLIGHTS
Ensign Electric & Mfg. Co.
Flood City Brass & Electric Co.
General Electric Co., Lamp Div. —"GENERAL ELECTRIC"
Guyan Machy. Co.—"GUYAN"
Imperial-Cantrell Mfg. Co.—"I. C."
Jeffrey Mfg. Co.

HEADLIGHTS, MINE LOCOMOTIVE
Schroeder Brothers Corp.

HEATER PANEL & UNITS
United States Rubber Co.—"USKON"

HEATERS, HOSE
United States Rubber Co.

HEATERS, OIL
Dravo Corp.
Hauck Mfg. Co.

HEATERS, UNIT
American Air Filter Co., Inc.
American Blower, Div of American-Standard "BENTURAFIN"
Buffalo Forge Co.
E. K. Campbell Co.—"THERMIDAIRE"
Clarage Fan Co.
Dravo Corp.
Ilg Electric Ventilating Co.—"ILG"
Westinghouse Electric Corp., B. F. Sturtevant Div.—"SPEED-HEATERS"
L. J. Wing Mfg. Co. Div. of Aero Supply Mfg. Co. Inc.—"WING REVOLVING"

HEATING CABLE, LEAD-SHEATHED
Rockbestos Products Corp.

HEATING PLANTS
Axeman-Anderson Co.
Dravo Corp.

HEAVY-MEDIA RECLAMATION SYSTEMS
Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"AKINS"
The Daniels Co. Contractors, Inc.—"DMS"
Nelson L. Davis Co.—"NELD-CO"
Denver Equipment Co.—"DECO"
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Simplicity Engineering Co.
Western Machinery Co.—"WEMCO"

HEAVY-MEDIA SEPARATION PROCESS
Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"AIKINS"
The Daniels Co. Contractors, Inc.—"DMS"
Nelson L. Davis Co.—"NELD-CO"

Dravo Corp.
Fairmont Machinery Co.
Fuel Process Co.
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Southwestern Engineering Co.
Stearns Magnetic Products
Western Machinery Co.—"WEMCO MOBIL-MILL"

HEAVY-MEDIA SEPARATORS
Hardinge Co., Inc.
Link-Belt Co., Dept. CAMGL-58

HEEL BLOCKS, SWITCH
Bethlehem Steel Co.

HIGH VOLTAGE INTERRUPTING DEVICES
Delta-Star Electric Div., H. K. Porter Co. (Delaware)

HINGES, MINE-DOOR
National Mine Service Co. (Clarkson Div.)—"CLARKSON"

HITCHINGS, MINE-CAR
American Car & Foundry Div., ACF Industries, Inc.
C. S. Card Iron Works
Duquesne Mine Supply Co.
Enterprise Wheel and Car Corp.
Irwin Foundry & Mine Car Co.
National Malleable & Steel Castings Co.
Sanford Day Iron Works, Inc.

HOIST CONTROLLERS
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Clark Controller Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
Industrial Physics & Electronics Co.
Morse Bros. Machinery Co.
Shepard Niles Crane & Hoist Corp.
Vulcan Iron Works

HOIST HOOKS
Crosby Laughlin Div., American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
E. D. Bullard Co.
Duquesne Mine Supply Co.
Upson-Walton Co.

HOIST SIGNALLING COMMUNICATION
Femco, Inc.—"CAGE-PHONE"
Industrial Physics & Electronics Co.
Mine Safety Appliances Co. — "HOISTPHONE"

HOISTS, AIR
Gardner-Denver Company
Ingersoll-Rand Co.
Joy Mfg. Co.
Manning, Maxwell & Moore, Inc. Shaw-Box Crane & Hoist Div.—"BUDGIT," "LOAD LIFTER"

HOISTS, CONSTRUCTION
American Hoist & Derrick Co.

HOISTS, ELECTRIC
American Engineering Co. — "LO-HED"
J. D. Christian Engineers
Coffing Hoist Div., Duff-Norton Co.—"QUIK-LIFT"
Guyan Machy. Co.—"SHAW-BOX"
Harnischfeger Corp.—"ZIP-LIFT," "HEVILIFT"
Robert Holmes & Bros., Inc.
Ingersoll-Rand Co.
Joy Mfg. Co.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"BUDGIT," "LOAD LIFTER"

Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Robbins & Myers, Inc.—"R & M"
Joseph T. Ryerson & Son, Inc.
Sanford Day Iron Works, Inc.
Sauerman Bros., Inc.
Shepard Niles Crane & Hoist Corp.
The Stearns-Roger Mfg. Co.
Stephens-Adamson Mfg. Co.
Vulcan Iron Works
Yale & Towne Mfg. Co. — "MIDGET KING," "CABLE KING," "LOAD KING"

HOISTS, ELECTRIC AND GASOLINE
Clyde Iron Works, Inc.

HOISTS, GASOLINE
Joy Mfg. Co.

HOISTS, HAND
J. D. Christian Engineers
Coffing Hoist Div., Duff-Norton Co.—"SAFETY PULL," "SUPER POWER"
Denver Equipment Co. — "DENVER"
Harnischfeger Corp.
Robert Holmes & Bros., Inc.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"BUDGIT," "TUGIT," "SHAW BOX"
Morse Bros. Machinery Co.
Ore Reclamation Co.
Robbins & Myers, Inc.—"R & M"
Joseph T. Ryerson & Son, Inc.
Stephens-Adamson Mfg. Co.
Yale & Towne Mfg. Co. — "PUL-LIFT," 'LOAD KING"

HOISTS, LAYER-LOADING
Robert Holmes & Bros, Inc.
Sanford Day Iron Works, Inc.

HOISTS, LOADING-BOOM
Morse Bros. Machinery Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Sanford Day Iron Works, Inc.
Shepard Niles Crane & Hoist Corp.

HOISTS, MONORAIL
American Engineering Co.—"LO-HED"
Coffing Hoist Div., Duff-Norton Co.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"BUDGIT," "TUG-IT," "SHAW BOX"
Robbins & Myers, Inc.—"R & M"
Joseph T. Ryerson & Son, Inc.
Shepard Niles Crane & Hoist Corp.

HOISTS, PORTABLE
Chicago Pneumatic Tool Co.
Coffing Hoist Div., Duff-Norton Co.
Denver Equipment Co.—"DENVER"
Flood City Brass & Electric Co.
Guyan Machy. Co.—"BUDGIT"
Harnischfeger Corp.
Ingersoll-Rand Co.
Joy Mfg. Co.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"BUDGIT," "TUG-IT," "SHAW BOX"
Robbins & Myers, Inc.—"R & M"
Ruger Equipment, Inc.
Joseph T. Ryerson & Son, Inc.
Schroeder Brothers Corp.
Shepard Niles Crane & Hoist Corp.
Yale & Towne Mfg. Co.

HOISTS, SCRAPER
American Hoist & Derrick Co. —"AMERICAN"
Ingersoll-Rand Co.

Joy Mfg. Co.
Sauerman Bros., Inc.

HOISTS, SHAFT
Connellsville Mfg. & Mine Supply Co.
Robert Holmes & Bros., Inc.
Joy Mfg. Co.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div.—"SHAW-BOX"
Mayo Tunnel & Mine Equipment
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Vulcan Iron Works

HOISTS, SHAFT, FRICTION-TYPE
Connellsville Mfg. & Mine Supply Co.

HOISTS, SKIP
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58

HOISTS, SLOPE
Robert Holmes & Bros., Inc.
Joy Mfg. Co.
Morse Bros. Machinery Co.
Nordberg Mfg. Co.
Vulcan Iron Works

HOISTS, TRUCK-BODY
Galion Allsteel Body Co.
Gar Wood Industries, Inc.
Hercules Steel Products Co.
Hockensmith Corp.—"PENN"
Marion Metal Products Co.
Perfection Steel Body Co.
Vickers, Inc., Tulsa Winch Div.

HOLDBACKS, CONVEYOR
Link-Belt Co., Dept. CAMGL-58
Stephens-Adamson Mfg. Co.

HOPPERS—See Bins & Hoppers, Coal, Storage & Blending

HOPPERS, WEIGH
Robert Holmes & Bros., Inc.
Industrial Physics & Electronics Co.
The Nolan Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Stephens-Adamson Mfg. Co.

HOSE ASSEMBLIES, SPLIT FLANGE
Anchor Coupling Co. Inc.

HOSE, AIR
Acme Machinery Co.
Aeroquip Corp.
Anchor Coupling Co., Inc.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Chicago Pneumatic Tool Co.
Eimco Corp.
The Gates Rubber Co. Sales Div., Inc.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"COMMANDER-TYPE 88," "TYPE 50-MAX-EGON ALL PURPOSE"
Goodyear Tire & Rubber Co.
Guyan Machinery Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins Incorporated—"MONARCH," "AJAX," "HEWITT," "MALTESE CROSS"
Industrial Rubber Products Co. (Pa.)
Joy Mfg. Co.
Lincoln Engrg. Co. Div. of McNeil Mach. & Engrg. Co.
Olin-Mathieson Chemical Corp., Explosives Div.
Ore Reclamation Co.
Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rub-

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

Exide®-IRONCLAD BATTERIES—

speed hauling, reduce costs

Want to cut your mine vehicle operating costs—boost productivity? Install Exide-Ironclad Batteries. These heavy-duty units give you that extra reserve of power that lets you make more trips per shift, get more production per man-hour, haul as much the last hour as the first. And because of their proven long life, even in the most severe service, they effectively reduce the cost of your battery power.

Make sure you are getting the maximum possible utility from your mine vehicles. Specify Exide-Ironclad Batteries. Available in a range of sizes to cover the requirements of every application.

EXCLUSIVE EXIDE-IRONCLAD ADVANTAGES:

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⅓ greater effective plate area—power to spare for peak loads as well as a dependable source of power for continuous loads.

Longer plate life—active material is held firmly captive inside cylindrical power tubes, maintains electrical contact, can't shear off during cycling.

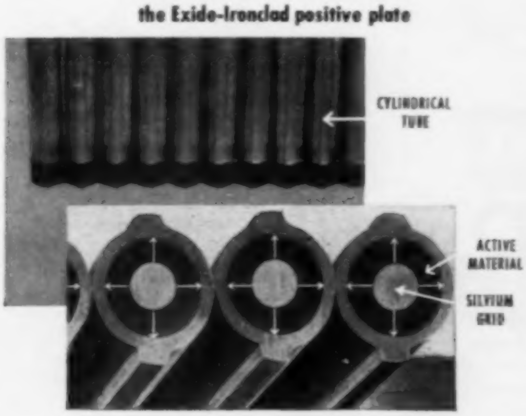
Pools of electrolyte next to plates—speed response to heavy load demands, insure maximum power from battery at all times, without delay.

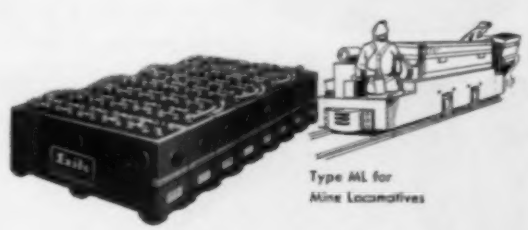
Silvium grids—exclusive patented Exide grid alloy resists corrosion, prolongs strength and thickness of grids, stretches battery life.

Vibration resistant—active material protected from shedding by cylindrical tubes, tiny openings let electrolyte in but keep active material from falling out; battery lasts longer in high vibration applications.

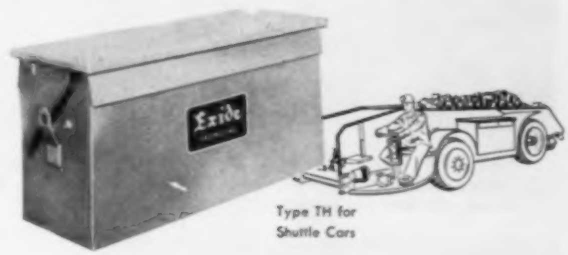
More active oxides—increase battery capacity, give Exide-Ironclad Batteries more power per pound; hence they have greater electrical efficiency.

Exclusive tubular construction of the Exide-Ironclad positive plate

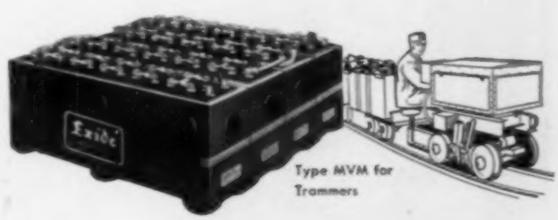




Type ML for Mine Locomotives



Type TH for Shuttle Cars



Type MVM for Trammers

For prices, specifications or free manual on maintaining motive power batteries, call or write the Exide sales office near you.

ATLANTA 10, GA.	1246 Allene Ave., S.W.
BOSTON 34, MASS.	100 Ashford Street
CHICAGO 9, ILL.	5335 S. Western Blvd.
CLEVELAND 14, OHIO	1014 Engineers Bldg.
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DETROIT 4, MICH.	8051 W. Chicago Blvd.
KANSAS CITY 23, MO.	129 S. Belmont Blvd.
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MINNEAPOLIS 3, MINN.	1750 Hennepin Avenue
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PHILADELPHIA 4, PA.	101 N. 33rd Street
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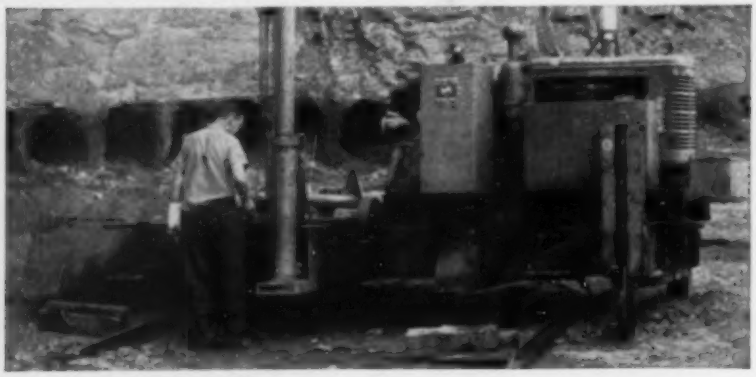
ST. LOUIS 8, MO.	3928 Lindell Blvd.
SAN FRANCISCO 24, CALIF.	6150 Third Street
SEATTLE 1, WASH.	500 Wall St.
WASHINGTON 6, D.C.	1819 "L" Street, N.W.



ber & Tire Co.—"TOWER"
Schroeder Brothers Corp.
Thermoid Co.
Thor Power Tool Co.
United States Rubber Co.
Weatherhead Co., Fort Wayne Div.

HOSE, AIR-SHOOTING

Aeroquip Corp.
Central Mine Supply Div., Pickard Industries, Inc.—"SEALTITE"

HOSE, CLAMPS

Hose Accessories Co.

HOSE, COAL WASHING

B. F Goodrich Industrial Products Co.—"CONVERTA-PIPE"

HOSE, CONDUIT

Guyan Machy. Co.

HOSE, FIRE

American LaFrance Corp.—"American LaFrance"
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Carlyle Rubber Co., Inc.
Fyr-Fyter Div.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"PINNACLE," "COMMANDER," "SOLAR," "MAINSTAY," "CASCADE," "B.F.G.," "SIGNAL"
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins Incorporated—"AJAX," "MONARCH," MALTESE CROSS"
Industrial Rubber Products Co. (Pa.)
Mine Safety Appliances Co.
Quaker Rubber Div., H. K. Porter Co., Inc.—"Quaker", "Quaker Pioneer"
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rubber & Tire Co.—"Republic"
United States Rubber Co.

HOSE, FLEXIBLE

Aeroquip Corp.
Anchor Coupling Co., Inc.
Boston Woven Hose & Rubber Co.
Cobra Metal Hose, Div. DK Mfg. Co.
Compton, Inc.
Farris Flexible Valve Corp.—"FLEX VALVE," "SUPER SEAL"
Flexaust Co.—"FLEXAUST"
Franklin Plastics, Inc.—"DUR X PLASTIC," "CROWN"
Goodall Rubber Co.
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Thermoid Co.
United States Rubber Co.
Weatherhead Co., Fort Wayne Div.

HOSE, FLEXIBLE METAL

Cobra Metal Hose, Div. DK Mfg. Co.

HOSE, FLEXIBLE, MINE

Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Eimco Corp.
Franklin Plastics, Inc.—"DUR X PLASTIC," "INDUSTRIAL"
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"CONVERTA-PIPE"

Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Thermoid Co.

HOSE, GAS

Hewitt-Robins Incorporated
Raybestos Manhattan, Inc., Manhattan Rubber Div.
United States Rubber Co.

HOSE, GASOLINE

B. F. Goodrich Industrial Products Co.—"TYPES 72, 72-A, 72-W PUMP HOSE," "TYPE 79 & 82-A TANK HOSE," "TYPES 83 & 83-A FUEL OIL HOSE"

HOSE, GREASE & OIL

Aeroquip Corp.
Boston Woven Hose & Rubber Co.
Continental Rubber Works—"VITALIC," "LIBERTY," "TRIBUNE," "ENDURO"
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Lincoln Engrg. Co. Div. of McNeil Mach. & Engrg. Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rubber & Tire Co.
Stewart-Warner Corp., Alemite Div.
Thermoid Co.
Weatherhead Co., Fort Wayne Div.

HOSE, HYDRAULIC

Aeroquip Corp.
Anchor Coupling Co., Inc.
Blackhawk Mfg. Co.
Carlyle Rubber Co., Inc.
Central Mine Supply Co. Div., Pickard Industries, Inc.—"SEALTITE"
Champ Industries Inc.
Continental Rubber Works—"VITALIC," "LIBERTY," "TRIBUNE," "ENDURO"
Flood City Brass & Electric Co.
The Gates Rubber Co. Sales Div., Inc.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Guyan Machy. Co.—"EASTMAN"
Hewitt-Robins Incorporated
Hose Accessories Co.
Industrial Rubber Products Co. (Pa.)
Mining Machine Parts, Inc.
National Mine Service Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rubber & Tire Co.—"WIRETEX"
Schroeder Brothers Corp.
Stewart Warner Corp., Alemite Div.
Thermoid Co.
United States Rubber Co.
Weatherhead Co., Fort Wayne Div.

HOSE, ROCK-DUST

American Mine Door Co.
B. F. Goodrich Industrial Products Co.—"DUSTEX"
Mine Safety Appliances Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.

HOSE, STEAM

Aeroquip Corp.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins Incorporated
Raybestos Manhattan, Inc., Manhattan Rubber Div.
United States Rubber Co.

Duff-Norton Jacks

HOSE, SUCTION, DISCHARGE

Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Cincinnati Rubber Mfg. Co., Div. of Thor Power Tool Co.
Continental Rubber Works—"VITALIC," "LIBERTY," "TRIBUNE," "ENDURO"
The Gates Rubber Co. Sales Div., Inc.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"CASCADE," "MAXECON," "MORECON," "SPIROLOCK," "TYPE 81 FOR WATER," "TYPES 400, 200, 150, 100, FOR OIL," "TYPE 82-A FOR GASOLINE"
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rubber & Tire Co.
Thermoid Co.
United States Rubber Co.

HOSE, WATER

Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Cincinnati Rubber Mfg. Co., Div. of Thor Power Tool Co.
Continental Rubber Works—"VITALIC," "LIBERTY," "TRIBUNE," "ENDURO"
Flood City Brass & Electric Co.
Franklin Plastics, Inc.—"DUR X PLASTIC," "SUPREME"
The Gates Rubber Co. Sales Div., Inc.
Gering Products, Inc.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"JUPITER DELUGE ALARM"
Goodyear Tire & Rubber Co.
Hamilton Rubber Mfg. Corp.
Hewitt-Robins Incorporated—"MONARCH," "AJAX," "HEWITT"
Industrial Rubber Products Co. (Pa.)
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.
Ore Reclamation Co.
Plymouth Rubber Co. Inc.
Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Republic Rubber Div., Lee Rubber & Tire Co.—"TONKA"
Thermoid Co.
United States Rubber Co.

HOSE FITTINGS

Aeroquip Corp.—"SOCKETLESS," "LITTLE GEM," "SUPER GEM"
Anchor Coupling Co., Inc.
Boston Woven Hose & Rubber Co.
Carlyle Rubber Co., Inc.
Cincinnati Rubber Mfg. Co., Div. of Thor Power Tool Co.
Continental Rubber Works
Flood City Brass & Electric Co.
The Gates Rubber Co. Sales Div., Inc.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Industrial Rubber Products Co. (Pa.)
Hewitt-Robins Incorporated
Hose Accessories Co.
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.
Mining Machine Parts, Inc.
Parker Fittings & Hose Div., Parker Hannifin Corp.—"HOZE-LOK"
Schroeder Brothers Corp.
Standard Devices Co.
Weatherhead Co., Fort Wayne Div.

HOSE FITTINGS, DETACHABLE & REUSABLE

Aeroquip Corp.
Anchor Coupling Co., Inc.
Carlyle Rubber Co., Inc.
Continental Rubber Works
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Hose Accessories Co.
C. B. Hunt & Son, Inc.—"QUIK-AS-WINK"
Industrial Rubber Products Co. (Pa.)
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co. —"LOKTITE"
Mining Machine Parts, Inc.
Schroeder Brothers Corp.
Standard Devices Co.
Thermoid Co.
Weatherhead Co., Fort Wayne Div.

HOSE FITTINGS, HYDRAULIC

Aeroquip Corp.
Anchor Coupling Co., Inc.
Carlyle Rubber Co., Inc.
Champ Industries Inc.
Compton, Inc.
Continental Rubber Works
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Hose Accessories Co.
Industrial Rubber Products Co. (Pa.)
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Schroeder Brothers Corp.
Standard Devices Co.
Stewart-Warner Corp., Alemite Div.
Thermoid Co.
United States Rubber Co.
Weatherhead Co., Fort Wayne Div.

HOSE FITTINGS, SWAGED

Weatherhead Co., Fort Wayne Div.

HOSE & TUBE COMBINATIONS

Anchor Coupling Co. Inc.

HYDRAULIC ACCUMULATORS

Parker Hydraulics Div., Parker-Hannifin Corp.—"PARKER"
Schroeder Brothers Corp.

HYDRAULIC ACTUATORS

R. H. Sheppard Co., Inc.

HYDRAULIC CONTROL UNITS

Caterpillar Tractor Co.

HYDRAULIC CYLINDERS

Blackhawk Mfg. Co.
Joy Mfg. Co.
Kalamazoo Div., New York Air Brake Co.—"HYDRECO"
Ledeen, Inc.
Schroeder Brothers Corp.
Star Jack Co., Inc.
Vickers Incorporated

HYDRAULIC CYLINDERS PUMPS, VALVES, REBUILT

Leman Machine Co.

HYDRAULIC FLUID

The American Oil Co.
Cities Service Oil Co.
D-A Lubricant Co., Inc.—"D-A"
Esso Standard Oil Co.—"TERESSO," "ESSTIC," "NUTO," "NURAY," "CORAY"
Hulbert Oil & Grease Co.
Keystone Lubricating Co.
Shell Oil Co.
Sinclair Refining Co.—"DURO"
Socony Mobil Oil Co. Inc.
Sun Oil Co.—"SOLNUS," "SUNTAC," "SUNVIS"

HYDRAULIC FLUIDS, FIRE-RESISTANT

Monsanto Chemical Co., Organic Chemicals Div.
Shell Oil Co.
Socony Mobil Oil Co. Inc.
Swan-Finch Petrochemicals

HYDRAULIC POWER UNITS

Schroeder Brothers Corp.

HYDRAULIC PUMPS

American Engineering Co. — "HELE-SHAW," "HYRAMITE"
Baughman Mfg. Co., Inc.
Blackhawk Mfg. Co.
Compton, Inc.
Denison Engineering Div., American Brake Shoe Co.
Gar Wood Industries, Inc.
Joy Mfg. Co.
Kalamazoo Div., New York Air Brake Co.—"HYDRECO"
Schroeder Brothers Corp.
Star Jack Co., Inc.
Vickers Incorporated
Worthington Corp.

HYDRAULIC PUMPS, REBUILDING, REPAIR

Meckum Engr. Co.
Vickers Incorporated
West Virginia Armature Co.

HYDRAULIC PUMPS, REBUILT

National Mine Service Co.

HYDRAULIC STEERING GEARS

R. H. Sheppard Co., Inc.

HYDRAULIC SYSTEMS CENTRAL

Aldrich Pump Co.

HYDRAULIC VALVES

Blackhawk Mfg. Co.
A. W. Cash Co.
Denison Engineering Div., American Brake Shoe Co.
C. B. Hunt & Son, Inc.—"QUIK-AS-WINK"
Kalamazoo Div., New York Air Brake Co.—"HYDRECO"
Ledeen, Inc.
The Lunkenheimer Co.—"LUNKENHEIMER"
Parker Hydraulic Div., Parker-Hannifin Corp.—"PARKER"
Schroeder Brothers Corp.
Star Jack Co., Inc.
Vickers Incorporated
Walworth Co.

HYDROSEPARATORS

Bird Machine Co.
Denver Equipment Co.—"DENVER," "HYDRO-CLASSIFIER"
Dorr-Oliver, Inc.
Hardinge Co., Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Western Machinery Co.—"WEMCO"

INDICATING LIGHTS

Cutler-Hammer, Inc.—"PRES-TEST"

INDICATORS, DATA-DISPLAY AND TRANSFER

Union Switch & Signal Div. of Westinghouse Air Brake Co.

INDICATORS, REMOTE

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
B-I-F Industries, Inc.
The Bristol Co.—"BRISTOL'S"
Fischer & Porter Co.
General Electric Co., Apparatus Sales Div.
Hays Corp.
Industrial Physics & Electronics Co.

INDICATORS, SIGHT-FEED AND WATER

The Lunkenheimer Co.—"LUNKENHEIMER"

INDICATORS, TEMPERATURE

West Instrument Corp.—"VERI-TELL"

INSTRUMENTS, BLASTING-VIBRATION

King Powder Co., Inc.
W. F. Sprengnether Instrument Co., Inc.

INSTRUMENTS, FLOW-INDICATING

New Jersey Meter Co.—"FLO-SIG," "TOOL-OM-ETER," "DRILL-OM-ETER"

INSTRUMENTS—HYDRAULIC CIRCUIT TESTING

Schroeder Brothers Corp.

INSTRUMENTS, RECORDING, PRESSURE, TEMPERATURE, ETC.

B-I-F Industries, Inc.—"FLO-WATCH," "CHRONOFLO"
The Bristol Co.—"BRISTOL'S"
Fischer & Porter Co.
Fisher Scientific Co.
Foxboro Co.
Hays Corp.
Industrial Physics & Electronics Co.
West Instrument Corp.—"MARKSMAN"

INSTRUMENTS, RECORDING PRESSURE, FLOW, TEMPERATURE, ETC.

Minneapolis-Honeywell Regulator Co., Industrial Div.

INSTRUMENTS, ROOF-CONTROL

Herold Mfg. Co.

INSULATING MATERIALS, ELECTRIC

Dow Corning Corp.
Duquesne Mine Supply Co.
General Electric Co., Chemical and Metallurgical Div., Insulating Materials Section—"IRRATHENE"
Irvington Div. of Minnesota Mining & Mfg. Co.
Johns-Manville—"FIBROID," "ARMATURO," "QUINTERRA," "QUINTERRA-BORD" "QUINORGO," "QUINORGOBORD"
Keasbey & Mattison Co.
Minnesota Mining & Mfg. Co. —"SCOTCHFIL," "SCOTCH CAST" RESIN
National Electric Coil Co.
Pennsylvania Electric Coil Corp.
Shell Oil Co.
United States Rubber Co.
West Virginia Armature Co.
Westinghouse Electric Corp.

INSULATING MATERIALS, HEAT & COLD

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Johns-Manville — "SUPER-EX," "ASBESTO-SPONGE," "THERMOBESTOS," "ROC CORK," "ZEROLITE," "FIBROCEL," "THERMO-FLEX," "ASBESTOCEL," "SPINTEX," "BANROC"
Keasbey & Mattison Co.
Mexico Refractories Co.—"PLASTIC," "VEE-BLOCK CASTABLE," "M-5," "I-R-C"
Pittsburgh Corning Corp.—"FOAMGLAS"
Pittsburgh Plate Glass Co.—"PPG FIBER GLASS"
The Ruberoid Co.
United States Rubber Co.

INSULATING MATERIALS, NOISE

Johns-Manville — "SPIN-

Duff-Norton Jacks

are safer, sturdier, faster, more economical—meet every modern mining need!

SINGLE ACTION RATCHET LOWERING JACKS WITH FOOT LIFT

514-MT
516-MT
521-MT

1017
1020
1022

1522
1528

2028

5 TONS Furnished with double round sockets and steel operating lever 1" x 30". *When jack is not under load,* head can be dropped or tripped instantly.

10 TONS Furnished with either of the following sockets and operating levers: double round or small single round and steel lever 1¼" x 60"; large round and wooden lever 2⅛" x 48"; or square socket to fit your own lining bar.

15 TONS Double round socket and steel lever bar 1¼" x 60" long are standard equipment. Also furnished with large round socket and wood operating lever 2⅛" x 48" long; or square socket to fit your lining bars.

20 TONS Double round sockets and steel lever 1¼" x 60". Also furnished with small single round socket; large round socket with wooden lever 3⅛" x 66"; or square socket to fit your lining bar.

Jacks can be furnished with either curved or flat tops.

Every Duff-Norton ratchet jack is guaranteed at full capacity for loads applied to either head or foot lift.

Jack No.	514-MT	516-MT	521-MT	1017	1020	1022	1522	1528	2028
Cap. Tons	5	5	5	10	10	10	15	15	20
Ht. Ins.	14	16	21	17⅛	20	22	22	28	28
Raise Ins.	7½	9½	14½	9	10½	12½	11½	17½	18
Ft. Lift Ht. Ins.	1½	1½	1½	2⅛	2⅛	2⅛	2½	2½	2½
Weight Lbs.	31	34	41	55	59	65	82	96	103

*Duff-Norton Patented spring mechanism, one complete unit—easily replaced.

MINE ROOF JACKS AND FITTING

Factory made complete jacks.
8—16 Tons
MR-8
MR-16

Make-it-yourself fittings.
8—16 Tons
MR-80
MR-160

Angle Jack
8—16 Tons

Pin timbering jacks
8—16 Tons

For pin timbering or angle jacks with square tubing, specify MR-8-P or MR-16-P. For round tubing, specify MR-80-P or MR-160-P.

JACK FITTINGS The following five heads, three handles, and three bases are available in any combination:

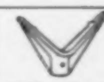
HEADS

TYPE "H"—used with 4" H-Beams or rails.

TYPE "B"—ball and socket for flat timbers, beams or direct contact.

TYPE "T"—6½", 8¼", and 11¼" sizes for H-beams, round or square timbers.

TYPE "L"—for angle support of ends of timbers, beams or rails.



TYPE "V"—for various diameter round timbers.

HANDLES

SLIDE HANDLE—for extra leverage in close quarters.

DROP HANDLE—similar to the slide handle except it folds down when not in use.

WING NUT HANDLE—for open areas where a firm, two-handed grip is possible.

BASES

ROUND BASE—cored pocket to fit on standard or extra strong pipe, with 7/16" diameter hole to fasten fitting to pipe. Use with ⅜" diameter bolt.

ROUND FISHTAIL BASE—cored pocket to fit standard or extra strong pipe, with 7/16" diameter hole to fasten fitting to pipe. Use ⅜" diameter bolt. End grooved to fit over 1½" diameter pin.

SQUARE FISHTAIL BASE—cored pocket to fit over end of square tubing, with 7/16" diameter hole to fasten fitting to pipe. Use with ⅜" diameter bolt. End is grooved to fit over 1½" diameter pin.

MR-8 or MR-8-P (Capacity 8 tons)
MR-16 or MR-16-P (Capacity 16 tons)

Minimum Height Closed	Maximum Height Open	MR-8 Weight Pounds	MR-16 Weight Pounds
30"	45"	31	45
36"	51"	33	48
42"	57"	34	51
48"	63"	36	54
54"	69"	38	56
60"	75"	40	59
66"	81"	42	62
72"	87"	43	65

PIPE NOT FURNISHED

Jack No.	Capacity Tons	Screw Dia Inches	Screw Raise Inches	Pipe Column to be used
MR-80 or MR-80-P	8	1½	15	2" Standard
MR-160 or MR-160-P	16	1⅞	15	2" Extra Strength

Heights given are for type "B" heads. For other heads deduct 2" on MR-8 models, 1½" on MR-16 models. MR-8 screws are 1½" diameter. MR-16 screws 1⅞" diameter.

Write for Bulletin AD10—
"A Handy Guide for Selecting Mine Jacks."

Duff-Norton Company

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

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Keasbey & Mattison Co.—"SPRAYED LIMPET," "ASBESTOS"
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I-T-E Circuit Breaker Co.
Ohio Brass Co.

INSULATORS, RUBBER
Continental Rubber Works

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INSURANCE, PLANT & EQUIPMENT
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"SIMPLEX"
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Mining Progress, Inc.
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Cement Gun Co.—"GUNITE"

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Link-Belt Speeder Corp.
Tractomotive Corp.—"TRAC-TOLOADER"

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Specify Pressure-Treated . . .

MINE TIES CRIBBING
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Be sure to specify pressure treatment wherever wood must serve under severe conditions. Koppers is ready to supply creosoted or Wolmanized-treated materials to meet your specifications. For additional information, or the name of your local Koppers representative, write to Koppers Company, Inc., Wood Preserving Division, Pittsburgh 19, Pennsylvania.

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LOCKERS, STEEL

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National Electric Products Co.
The Palnut Co.—"PALNUT"
Republic Steel Corp.—"REPUBLIC NYLOK"

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Eimco Corp.

LOCOMOTIVES, BATTERY

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General Electric Co., Locomotive & Car Equipment Dept.
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Kersey Manufacturing Co., Inc.
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West Virginia Armature Co.

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General Electric Co., Locomotive & Car Equipment Dept.

LOCOMOTIVES, DIESEL, SURFACE

Brookville Locomotive Works
Diesel Energy Corp.

Plymouth Locomotive Works, Div. of The Fate-Root-Heath Co.—"PLYMOUTH TORQO-MOTIVE"
Vulcan Iron Works

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Mayo Tunnel & Mine Equipment
National Mine Service Co.
Plymouth Locomotive Works, Div. of The Fate-Root-Heath Co.—"PLYMOUTH MINE-O-MOTIVE"

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Differential Steel Car Co.
General Electric Co., Apparatus Sales Div.
General Electric Co., Locomotive & Car Equipment Dept.
Plymouth Locomotive Works, Div. of The Fate-Root-Heath Co.—"PLYMOUTH"
Vulcan Iron Works

LOCOMOTIVES, GASOLINE, SURFACE

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LOCOMOTIVES, REBUILT

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LOCOMOTIVES, STORAGE BATTERY

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General Electric Co., Apparatus Sales Div.
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Goodman Mfg. Co.
Ironton Engine Co.—"IRON-TON"
Jeffrey Mfg. Co.
Morse Bros. Machinery Co.
National Mine Service Co.
West Virginia Armature Co.

LUBRICANTS

The American Oil Co.
Ashland Oil & Refining Co.—"ASHLAND"
Bearings, Inc.—"LUBRIKO"
The Brooks Oil Co.—"LEAD-OLENE," "KLINGFAST"
Samuel Cabot, Inc.—"CABOT'S TASGON," "CABOT'S LUBRI-TASGON"
Cities Service Oil Co.
D-A Lubricant Co., Inc.—"D-A"
Joseph Dixon Crucible Co.
Dow Corning Corp.
Esso Standard Oil Co.—"PEN-O-LED EP," "DIOL DX-130," "CYLESSO," "CANTHUS," "ROXTONE," "AROX EP," "NEBULA EP," "ANDOK," "ESTAN," "CAZAR," 'COMAL," "NAKTA"
Gulf Oil Corp.
Hulburt Oil & Grease Co.
Keystone Lubricating Co.
New York & New Jersey Lubricant Co.—"NON-FLUID OILS"
Ohio Oil Co.
Pennsylvania Refining Co.
The Pure Oil Co.—"POCO PB GEAR LUBRICANTS"
Shell Oil Co.
Sinclair Refining Co.
Socony Mobil Oil Co. Inc.
Standard Oil Co. (Ind.)
Stewart-Warner Corp., Alemite Div.
Sun Oil Co.—"SOLNUS," SUNTAC,' 'SUNVIS"
Swan-Finch Petrochemicals—"AEROSOL"
The Texas Co.
Tidewater Oil Co.
Valvoline Oil Co., Div. of Ashland Oil & Refining Co.
Warren Refining & Chemical Co. — "PLASTILUBE," "BUSTRUX," "PLASTI-GEAR," "GREEN GOLD," "WARCO," "STAYS IN," "LITHOLUBE"
The Whitmore Mfg. Co.—"WHITMORE'S PRESSURE-PROOF"

LUBRICANTS, ROCK DRILL

Socony Mobil Oil Co. Inc.
Sun Oil Co.

LUBRICATING FITTINGS

Gray Co., Inc.
Guyan Machy. Co.—"ALEM-ITE"
Lincoln Engrg. Co., Div. of McNeil Mach. & Engr. Co.—"BULLNECK"
Stewart-Warner Corp., Alemite Div.

LUBRICATING GUNS

Joseph Dixon Crucible Co.
Gray Co., Inc.
Guyan Machy. Co.—"ALEM-ITE"
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co. —"LUBRIGUNS"
Schroeder Brothers Corp.
Stewart-Warner Corp., Alemite Div.

LUBRICATING SYSTEMS, AUTOMATIC

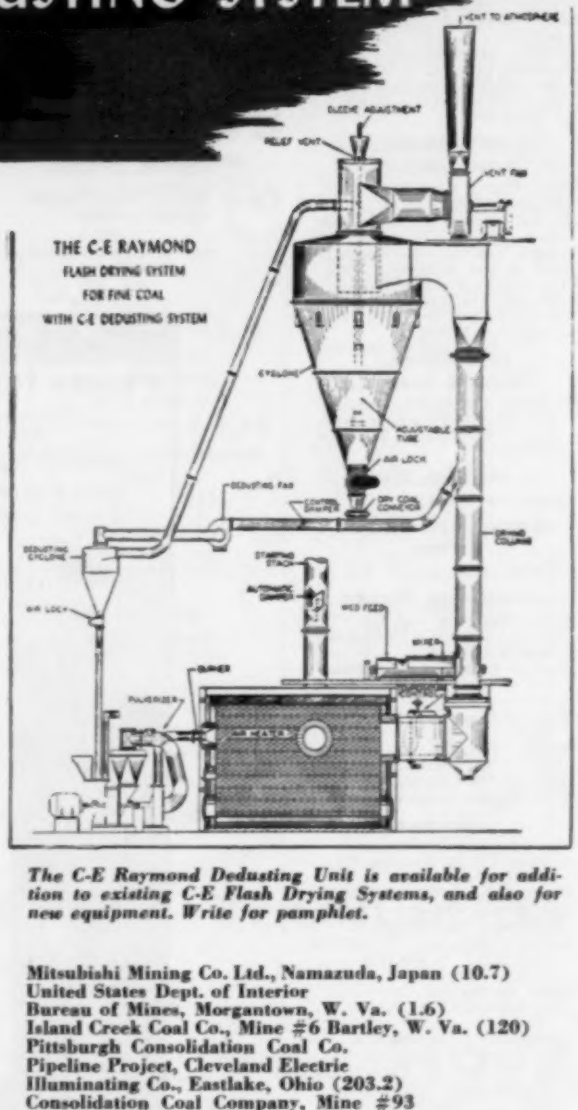
Farval Corp.
Gray Co., Inc.
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co. —"MULTILUBER"
Manzel Div., Houdaille Industries, Inc.
Nathan Mfg. Corp. — "NATHAN," "A," "P"
Stewart-Warner Corp., Alemite Div.
Trabon Engr. Corp.
Trico Fuse Mfg. Co.—"TRICO"

LUBRICATING SYSTEMS, CENTRALIZED

Farval Corp.
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co. —"CENTRO-MATIC"
Manzel Div., Houdaille Industries, Inc.
Nathan Mfg. Corp. —

C-E RAYMOND DEDUSTING SYSTEM

an important feature in the Flash Drying of Fine Coal



The C-E Raymond Dedusting Unit is available for addition to existing C-E Flash Drying Systems, and also for new equipment. Write for pamphlet.

The prime function of the Dedusting Unit is to remove the maximum amount of dust from the dried coal and burn the ultra-fines in a furnace to supply the heat for drying.

This provides a simple and effective method of handling two troublesome problems:

1. Vent loss to atmosphere
2. Loading nuisance

It has been shown that the vent loss from the cyclone is all minus 200-mesh material. This may be only ½ of 1% or less, yet it causes objectionable pollution in congested areas. Often this fraction is high in ash, and therefore tends to degrade the final product.

In drying the coal to the desired 3% moisture content, the tendency is to over-dry the ultra-fines, creating clouds of dust at all transfer points.

How efficiently the Dedusting Unit overcomes these difficulties is proven by tests conducted in some of the installations below. For example, the records show that where the feed averages 8.2% through 325-mesh, the finished dried coal product is only 1.3% of this nuisance material.

C-E RAYMOND Coal Drying Installations

Rochester & Pittsburgh Coal Co.
Kent Mines, McIntyre, Pa. (55)*
Hanna Coal Co., Piney Fork, Ohio (40)
Luzerne County Gas & Electric Corp.
Hunlock Power Sta., Kingston, Pa. (50)
Rochester & Pittsburgh Coal Co.
Lucerne Mines, Homer City, Pa. (175)
Island Creek Coal Co., Delbarton, W. Va. (65)
Drisco Company, Library, Penna. (42)
Kuesel Coal Company, Milwaukee, Wis. (15)
Eastern Gas and Fuel Associates
Wharton, Boone County, W. Va. (57)
Blue Diamond Coal Co., Leatherwood, Ky. (75)
Island Creek Coal Co., Delbarton, W. Va. (60)
Black Star Coal Corp., Alva, Ky. (60)
Hanna Coal Company, Adena, Ohio (160)
Red Jacket Coal Corp., Coal Mountain, W. Va. (40)
Clinchfield Coal Co., Dante, Va. (180)
Valley Camp Coal Co., Triadelphia, W. Va. (50)
Harmar Coal Co., Harmarville, Pa. (120)
(Formerly Consumers Mining Company)
Jamison Coal & Coke Co., Farmington, W. Va. (157)
Red Jacket Coal Corp., Red Jacket, W. Va. (70)
Eastern Gas & Fuel Associates
Wharton, Boone County, W. Va. (60)
Mitsubishi Mining Co. Ltd., Namazuda, Japan (10.7)
United States Dept. of Interior
Bureau of Mines, Morgantown, W. Va. (1.6)
Island Creek Coal Co., Mine #6 Bartley, W. Va. (120)
Pittsburgh Consolidation Coal Co.
Pipeline Project, Cleveland Electric
Illuminating Co., Eastlake, Ohio (203.2)
Consolidation Coal Company, Mine #93
Fairmont, W. Va. (200)
Jewell Ridge Coal Company
Tazewell, Virginia (68)
Bethlehem Steel Company for
Erie Mining Co., Emco, Minn. (36.5)
Carbon Fuel Co., Carbon, W. Va. (60)
Consolidation Coal Co., Jamison-Loveridge Mine,
Fairview, W. Va. (400)
Island Creek Coal Co., Mine #28,
Argonne, W. Va. (100)
Omar Mining Co., Omar, W. Va. (176)
Amherst Fuel Co., Slagle, W. Va. (190)
Tons of dry coal per hour

COMBUSTION ENGINEERING, INC.

Raymond Division

1315 North Branch St.
Chicago 22, Illinois

Sales Offices in Principal Cities

"NATHAN," "A," "P"
Stewart-Warner Corp., Alemite Div.
Trabon Engr. Corp.
Trico Fuse Mfg. Co.—"TRICO"

LUBRICATING SYSTEMS, CIRCULATING OIL

Trabon Engr. Corp.—"METER-FLO"

LUBRICATING SYSTEMS, MANUAL

Farval Corp.

LUBRICATING SYSTEMS, SPRAY, MANUAL, AUTOMATIC

Farval Corp.

LUBRICATORS

The Lunkenheimer Co.—"BANNER," "MAJOR," "INDEPENDENT," "PARAGON," "PENLO," "PREMIER," "SENIOR"

LUBRICATORS, FLANGE

Nathan Mfg. Co.
Transall, Inc.

LUBRICATORS, JOURNAL-BEARING

American Brake Shoe Co., Railroad Products Div.

LUBRICATORS, RAIL

American Brake Shoe Co., Railroad Products Div.

LUMBER, TREATED, UNTREATED

T. J. Moss Tie Co.

LUMBER & TIMBER

Republic Creosoting Co.

MACHINE & MOTOR MOUNTS

Dayton Rubber Co.

MACHINE GUARDS, PARTS FOR

Helmick Foundry-Machine Co.
Hendrick Mfg. Co.

MACHINES, CUSTOM-BUILT

National Mine Service Co.—"CLARKSON"

MAGNETS, PERMANENT NONELECTRIC

Crucible Steel Co. of America

MAGNETS, PLATE TYPE

Dings Magnetic Separator Co.

MAGNET WIRE

Crucible Steel Co. of America
General Electric Co., Construction Materials Div.
Rome Cable Corp.

MAGNETIC SEPARATORS

Eriez Mfg. Co.

MAGNETIZING BLOCKS

Dings Magnetic Separator Co.

MAGNETITE

The Daniels Co., Contractors, Inc.
Orefraction, Inc.

MAGNETITE RECOVERY DENSIFIERS

Colorado Iron Works Co., A Sub. of Mine & Smelter Supply Co.—"AKINS"
Western Machinery Co.—"WEMCO"

MAGNETITE RECOVERY SEPARATORS

The Daniels Co., Contractors, Inc.
Dings Magnetic Separator Co.
Eriez Mfg. Co.
Jeffrey Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Magnetic Engrg. & Mfg. Co.
Stearns Magnetic Products

MAGNETS, CHUTE-TYPE

Dings Magnetic Separator Co.
Eriez Mfg. Co.
Magnetic Engrg. & Mfg. Co.
Stearns Magnetic Products
Sprout, Waldron & Co., Inc.

MAGNETS, PERMANENT

Stacknole Carbon Co.—"CERAMAGNET"

MAGNETS, PERMANENT NONELECTRIC, CHUTE, PULLEY, SUSPENDED

Dings Magnetic Separator Co.
Eriez Mfg. Co.
The Homer Mfg. Div., The Ohio Electric Mfg. Co.—"HOMER"
Magnetic Engrg. & Mfg. Co.
W. J. Savage Co.
Stearns Magnetic Products
Transall, Inc.

MAGNETS, PULLEY-TYPE

Dings Magnetic Separator Co.
Eriez Mfg. Co.
Magnetic Engrg. & Mfg. Co.
Stearns Magnetic Products

MAGNETS, SUSPENDED

Dings Magnetic Separator Co.
Eriez Mfg. Co.
Magnetic Engrg. & Mfg. Co.
Stearns Magnetic Products

MAINTENANCE KITS, HYDRAULIC

Blackhawk Mfg. Co.

MALLETS, RUBBER

Goodyear Tire & Rubber Co.

MAPS, TOPOGRAPHIC, PHOTOGRAPHIC

Aerial Surveys, Inc.
Aero Service Corp.
American Air Surveys, Inc.
Jack Ammann Photogrammetric Engineers, Inc.

MASKS, DUST

Martindale Electric Co.

METALLIZING EQUIPMENT

Wall Colmonoy Corp.—"SPRAY WELDER"

METALLIZING WIRE

Crucible Steel Co. of America

METERS, COMPRESSED-AIR

New Jersey Meter Co.—"TOOL-OM-ETER," "DRILL-OM-ETER"

METERS

Analytical Measurements, Inc.

METERS, ELECTRICAL—See AMMETERS, ETC.

METERS, WATER, VENTURI

Infilco Inc.—"TWIN-THROAT"

MICA MAT

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

MICA, PASTED

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

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Bausch & Lomb Optical Co.
Fisher Scientific Co.

MILLING MACHINES

Farrel-Birmingham Co., Inc.
South Bend Lathe Works

MILLISECOND CONNECTORS, DETONATING FUSE

E. I. du Pont de Nemours & Co., Inc., Explosives Div.
King Powder Co., Inc.
Olin-Mathieson Chemical Corp., Explosives Div.

MILLS, BOWL, IMPACT, SCREEN, VERTICAL

Combustion Engineering, Inc.—"C-E-RAYMOND"

MILLS, LABORATORY

American Pulverizer Co.
Central Scientific Co.
Combustion Engineering, Inc.—"C-E-RAYMOND"
Denver Equipment Co.—"DENVER"
Fisher Scientific Co.
Sturtevant Mill Co.

MINE TIES, PRESSURE-CREOSOTED

Koppers Co., Inc., Wood Preserving Div.

MINE TIES, PRESSURE-TREATED

Koppers Co., Inc., Wood Preserving Div.—"WOLMANIZED"

MOILS

Howells Mining Drill Co.

MOISTURE-BARRIER PAPER

Fulton Bag & Cotton Mills

MOISTURE METERS

The Bristol Co.—"THERMO-HUMIDIGRAPH"
Heyl & Patterson, Inc.—"OLIVO"
Industrial Physics & Electronics Co.
Viking Machinery Sales Corp.

MOISTURE TESTERS

Analytical Measurements, Inc.

MORTAR, REFRACTORY

Johns-Manville — "SIL-O-CEL"
Mexico Refractories Co.—"LO-SET," "MEX-LOX," "MILL MORTAR," "BOND

SET," "HILOSET," "SUPER HILOSET"

MOTOR CONTROL CENTERS

Cutler-Hammer, Inc. — "UNITROL"

MOTOR CONTROLLERS, STARTERS

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Arrow Hart & Hegeman Electric Co.
Clark Controller Co.
Cutler-Hammer, Inc.—"C-H"
Electric Machinery Mfg. Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
F. R. Hannon & Sons— "HANCO"
Joy Mfg. Co.
Ohio Brass Co.
W. J. Savage Co.
Schroeder Bros.
Westinghouse Electric Corp.

MOTOR-GENERATOR SETS

Air Reduction Sales Co., A Div. of Air Reduction Co., Inc.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
The Louis Allis Co.
The Electric Products Co.
Electro Dynamic Div. of General Dynamics Corp.
Elliott Co.
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
F. R. Hannon & Sons— "HANCO"
Hobart Bros. Co.
Joy Mfg. Co.
The Lincoln Electric Co.— "SHIELD-ARC"
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Morse Bros. Machinery Co.
Reliance Elec. & Eng. Co.
Robbins & Myers, Inc.— "R & M"
Westinghouse Electric Corp.

MOTOR REWINDING, REDESIGN & REPAIRS

National Electric Coil Co.

MOTOR REWINDING, REPAIRS

Flood City Brass & Electric Co.
Guyan Machy. Co.
F. R. Hannon & Sons— "HANCO"
Joy Mfg. Co.
Pennsylvania Electric Coil Corp.
Scranton Electric Construction Co.
West Virginia Armature Co.
Westinghouse Electric Corp.

MOTORS, AC

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
The Louis Allis Co.
Bonded Scale & Machine Co.
J. D. Christian Engineers
Diehl Manufacturing Co.
Dooley Brothers
Electric Machinery Mfg. Co.
The Electric Products Co.
Electro Dynamic Div. of General Dynamics Corp.
Elliott Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
M. Glosser & Sons, Inc.
Guyan Machy. Co.
F. R. Hannon & Sons— "HANCO"
Joy Mfg. Co.
The Lincoln Electric Co.— "MULTIGUARD"
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Morse Bros. Machinery Co.
Mosebach Electric & Supply Co.
Reliance Elec. & Eng. Co.
Robbins & Myers, Inc.— "R & M"
W. J. Savage Co.
Schroeder Brothers Corp.
Sterling Electric Motors, Inc.— "STERLING"
U. S. Electrical Motors, Inc.— "UNICLOSED," "VARI-DRIVE," "SYNCROGEAR"
Wagner Electric Corp.
Westinghouse Electric Corp.

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Chicago Pneumatic Tool Co.
Eimco Corp.
Gardner-Denver Company
Joy Mfg. Co.—"TURBINAIR PISTONAIR"
Ingersoll-Rand Co.
Schroeder Brothers Corp.

MOTORS, DC

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The Louis Allis Co.
J. D. Christian Engineers
Diehl Manufacturing Co.
Dooley Brothers
Electro Dynamic Div. of General Dynamics Corp.
Elliott Co.
Ensign Electric & Mfg. Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
M. Glosser & Sons, Inc.
Guyan Machy. Co.
F. R. Hannon & Sons— "HANCO"
Joy Mfg. Co.
The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Morse Bros. Machinery Co.
Mosebach Electric & Supply Co.
Reliance Elec. & Eng. Co.
Robbins & Myers, Inc.— "R & M"
W. J. Savage Co.
Schroeder Brothers Corp.
Westinghouse Electric Corp.

MOTORS, FLUID

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The Master Electric Co., Div. of Reliance Electric & Eng. Co.
Schroeder Brothers Corp.
Vickers Incorporated

MUFFLERS

Fluor Products Co.

NAILS

American Steel & Wire Div., U.S. Steel Corp.

NEWSLETTERS, FOREMEN

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Black & Decker Mfg. Co.

NICKEL & NICKEL ALLOYS

International Nickel Co., Inc.

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The Lunkenheimer Co.— "LUNKENHEIMER"

NOZZLES, BLASTING

Norton Co.—"NORBIDE"

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Bete Fog Nozzle, Inc.
Fyr-Fyter Div.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
S. P. Kinney Engineers, Inc.

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The Branford Co.—"BRANFORD"
Chain Belt Co.—"REX"
The Deister Concentrator Co.— "CONCENCO"
Deister Machine Co.
The Duriron Co., Inc.
Fyr-Fyter Div.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Johnson-March Corp.
S. P. Kinney Engineers, Inc.
Link-Belt Co., Dept. CAMGL-58
Viking Machinery Sales Corp.
West Virginia Armature Co.
Worthington Corp.

NOZZLES, WET ROCK DUSTING

American Mine Door Co.
Mine Safety Appliances Co.

NUTS

Bethlehem Steel Co.
Central Mine Supply Co. Div., Pickard Industries, Inc.— "PROTECTO"
Guyan Machy. Co.
The Palnut Co. —"PALNUT"
Republic Steel—"REPUBLIC"
Sheffield Div., Armco Steel Corp.
Tamping Bag Co. Div., Pickard Industries, Inc.— "SPECIAL-SAFETY"

NUTS, MINE ROOF BOLTS

The Palnut Co.—"PALNUT"

OHMMETERS, MEGOHMMETERS

The Bristol Co.—"DYNA-MASTER"
Martindale Electric Co.
Westinghouse Electric Corp.

OIL, CUTTING, THREADING

The Ridge Tool Co.—"RIDG-OIL"

OILS HYDRAULIC— SEE HYDRAULIC FLUIDS

OILS

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Hulbert Oil & Grease Co.
Pennsylvania Refining Co.— "SERIES 3," "H. D."
The Pure Oil Co.—"PURO-PALE RX," "SULTANA X HEAVY DUTY"
Sinclair Refining Co.— "TENOL," "RUBILENE," "PENNANT E P," "OPALINE MULTI-PURPOSE," "JET," "SINCLAIR ONYX"
Socony Mobil Oil Co. Inc.
Swan-Finch Petrochemicals

OILS, AIR TOOL

New York & New Jersey Lubricant Co.
Socony Mobil Oil Co. Inc.

OILS, COMPRESSOR

Socony Mobil Oil Co. Inc.
Sun Oil Co.—"SOLNUS"

OILS, PENETRATING

Swan-Finch Petrochemicals— "AEROSOL"

OVERCASTS, CORRUGATED STEEL ROUND

Armco Drainage & Metal Prod., Inc.

OXYGEN-ADMINISTERING EQUIPMENT

Marathon Coal Bit Co. Inc.— "AIRCO"
Mine Safety Appliances Co.— "DEMAND PNEOPHORE," "PNEOLATOR," "PNEOPHORE," "PULMONARY VENTILATOR"

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Spang & Co.

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The Garlock Packing Co.
Goodall Rubber Co.
Goodyear Tire & Rubber Co.
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Industrial Rubber Products Co. (Pa.)
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Quaker Rubber Div., H. K. Porter Co., Inc.
Raybestos Manhattan, Inc., Manhattan Rubber Div.— "RM"
Republic Rubber Div., Lee Rubber & Tire Co.

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Flood City Brass & Electric Co.

PACKING, RUBBER

Hewitt-Robins Incorporated
United States Rubber Co.

PACKING, RUBBER, PLASTIC, ASBESTOS

B. F. Goodrich Industrial Products Co.

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Hewitt-Robins Incorporated

PACKINGS, ROD & SHEET

Industrial Rubber Products Co. (W. Va.)

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Bemis Bro. Bag Co.

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Joseph Dixon Crucible Co.
Magic Chemical Co.— "MAGIC-VULC"
E. I. du Pont de Nemours & Co., Inc.—"DUCO"® "DULUX"
Pittsburgh Plate Glass Co.— "PITTSBURGH"
Rust-Oleum Corp.
Sika Chemical Corp.—"SIKA-KOTE"
United States Rubber Co.
Wilbur & Williams Co.—"C.C. 40"

PAINTS, ALUMINUM

Joseph Dixon Crucible Co.
E. I. du Pont de Nemours & Co., Inc.
Magic Chemical Co.— "MAGIC-VULC"
Master Bronze Powder Co., Inc.—"BROMA"
Pittsburgh Plate Glass Co.— "PITTSBURGH"
Rust-Oleum Corp.
Wilbur & Williams Co.— "TOTALUME"

PAINTS, DAMP SURFACES

Wilbur & Williams Co.—

"DAMPCOAT"

PAINTS, ELECTRIC INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

PAINTS, INDUSTRIAL

Guyan Machy. Co.

PAINTS, REFLECTIVE

E. I. du Pont de Nemours & Co., Inc.
Pittsburgh Plate Glass Co.—"PITTSBURGH"

PAINTS, SPRAY, ALKYD ENAMEL

Master Bronze Powder Co., Inc.—"BROMA SPRAY IT YOURSELF"

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Clark Controller Co.—"AMERICAN"
Crouse-Hinds Co.
The Daniels Co., Contractors, Inc.
Hays Corp.
I-T-E Circuit Breaker Co.
Johns-Manville—"ASBESTOS EBONY," "OHMSTONE"
Westinghouse Electric Corp.

PANELS, INSTRUMENT

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Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell Regulator Co., Industrial Division
Stewart-Warner Corp., Alemite Div.
Westinghouse Electric Corp.

PAPER, ELECTRIC INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

PARTS, DRILLING MACHINES

Kensington Steel, Div. of Poor & Co.
Mobile Drilling, Inc.
Stardrill-Keystone Co.—"KEYSTONE," "STAR"

PARTS, LOCOMOTIVE

Flood City Brass & Electric Co.
Ironton Engine Co.—"IRONTON"
Jeffrey Mfg. Co.
Kelly Manufacturing Co., Machine Parts Div.
Mosebach Electric & Supply Co.
National Mine Service Co.
Penn Machine Co.
Pittsburgh Gear Co.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
West Virginia Armature Co.

PARTS, MINING MACHINERY

American Brake Shoe Co., Amsco Div.—"AMSCO"
American Brake Shoe Co., National Bearing Div.
Flood City Brass & Electric Co.
Guyan Machy. Co.
Howells Mining Drill Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kelly Mfg. Co., Machine Parts Div.
Kensington Steel, Div. of Poor & Co.
Marathon Coal Bit Co., Inc.—"MARATHON," "TRACY"
Mining Machine Parts Inc.
Mosebach Electric & Supply Co.
National Mine Service Co.
Penn Machine Co.
Pittsburgh Gear Co.
Taylor-Wharton Co., Div. Harsco Corp.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
West Virginia Armature Co.

PARTS, MOTOR, ELECTRICAL

Flood City Brass & Electric Co.
Jeffrey Mfg. Co.
Kelly Manufacturing Co., Machine Parts Div.
Reliance Elec. & Eng. Co.
Bertrand P. Tracy Co.
West Virginia Amrsature Co.

PARTS, PULVERIZER, MANGANESE

Kensington Steel, Div. of Poor & Co.

PARTS, SHUTTLE CAR

Flood City Brass & Electric Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Kelly Mfg. Co., Machine Parts Div.
National Mine Service Co.
Penn Machine Co.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
West Virginia Armature Co.

PARTS, TRUCK

C. S. Card Iron Works
Hendrickson Mfg. Co.
KW Dart Truck Co.

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Kern Instruments, Inc.

PH INDICATORS

Analytical Measurements, Inc.
Beckman Instruments, Inc., Process Instruments Div.
The Bristol Co.—"BRISTOL'S"
Fisher Scientific Co.
Foxboro Co.
Industrial Physics & Electronics Co.
Minneapolis-Honeywell Regulator Co., Industrial Div.
Scientific Instruments Div., Beckman Instruments, Inc.
Westinghouse Electric Corp.

PHOTOCOPY EQUIPMENT, MATERIALS

Peerless Photo Products, Inc.—"DRI-STAT"

PICKING TABLES

Bonded Scale & Machine Co.—"BONDED"
Fairmont Machinery Co.
Heyl & Patterson, Inc.
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kremser & Sons, Inc., Frank A.
Link-Belt Co., Dept. CAMGL-58
E. F. Marsh Engrg. Co.—"MARCO"
Morse Bros. Machinery Co.
Ore Reclamation Co.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Stephens-Adamson Mfg. Co.
Syntron Co.
Wilmot Engineering Co.

PICKS

The Bowdil Co.
The Leetonia Tool Co.

PILING

Republic Creosoting Co.

PILINGS, LIGHTWEIGHT STEEL SHEET

L. B. Foster Co.

PILING, TREATED, UNTREATED

T. J. Moss Tie Co.

PILLOW BLOCKS

Browning Mfg. Co.

PILLOW BLOCKS, ANTIFRICTION-BEARING

Ahlberg Bearing Co.—"AHLBERG"
Bearings, Inc.
Chain Belt Co.—"SHAFER"
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"SC-SCM-SLP," "SPHER-ALIGN"
The Fafnir Bearing Co.
Guyan Machy. Co.—"SEALMASTER"
Hewitt-Robins Incorporated—"JONES"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT" "JPS," "MILLBEARING," "SPHERICAL"
SKF Industries, Inc.
Stephens-Adamson Mfg. Co.—"SEALMASTER"
Transall, Inc.
Wilmot Engineering Co.

PILLIW BLOCKS, SEALMASTER

Guyan Machy. Co.

PILLOW BLOCKS, SLEEVE-BEARING

Bearings, Inc.
Chain Belt Co.—"REX"
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"SLEE-VOIL"
Joy Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
K. Prins & Associates
Transall, Inc.
Wilmot Engineering Co.

PINIONS

Hewitt-Robins Incorporated

PIPE

M. Glosser & Sons Inc.

PIPE, ALLOY STEEL

L. B. Foster Co.

PIPE, ALUMINUM

Aluminum Company of America—"ALCLAD"
L. B. Foster Co.
Guyan Machy. Co.
Kaiser Aluminum & Chemical Sales Co.
Revere Copper & Brass Inc.
Reynolds Metals Co.

PIPE, ASBESTOS-CEMENT

Guyan Machy. Co.—"TRANSITE"
Johns - Manville — "TRANSITE"
Keasbey & Mattison Co.

PIPE, BRONZE

Ampco Metal, Inc.

PIPE, CARBIDE-COATED

American Alloy Corp.

PIPE, CAST-IRON

United States Pipe & Foundry Co.
Wilmot Engineering Co.

PIPE, CEMENT-LINED

Jones & Laughlin Steel Corp.
United States Pipe & Foundry Co.

PIPE, COPPER, RED BRASS

Phelps Dodge Copper Products Co.
Revere Copper & Brass Inc.
Triangle Conduit & Cable Co., Inc.

PIPE, CORROSION-RESISTANT

A. M. Byers Co.
Duriron Co., Inc.

PIPE, CORRUGATED

Armco Drainage & Metal Prod., Inc.
Republic Steel—"REPUBLIC"

PIPE, DRIVE, AND DRIVING WINCHES

Acker Drill Co. Inc.—"MODEL RG and RGT"

PIPE, IRRIGATION, ALUMINUM

Aluminum Company of America
Reynolds Metals Co.

PIPE, PLASTIC

Amercoat Corp.—"BOND-STRAND"
A. M. Byers Co.
Carlon Products Corp.
Crane Co.
L. B. Foster Co.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.—"KOROSEAL"
Guyan Machy. Co.
Hamilton Rubber Mfg. Corp.—"POLYETHYLENE"
Industrial Rubber Products Co. (Pa.)
Johnson Plastic Corp.—"KRALASTIC"
Midland Pipe & Supply Co.
National Mine Service Co.
National Tube Div., United States Steel Corp.—"USS NATIONAL"
Quaker Rubber Div., H. K. Porter Co., Inc.
Republic Steel—"REPUBLIC"
Triangle Conduit Cable Co., Inc.
United States Rubber Co.
Yardley Plastics Co.—"CLEARSTREAM"
Youngstown Sheet & Tube Co.—"FIBERCAST"

PIPE, PLASTIC, FLEXIBLE

Irvington Div. of Minnesota Mining & Mfg. Co.

PIPE, PREFABRICATED

Fluor Products Co.

PIPE, RUBBER

Goodall Rubber Co.
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Industrial Rubber Products Co. (Pa.)
Linatex Corp. of America
Raybestos Manhattan, Inc. Manhattan Rubber Div.—"CONDOR"
United States Rubber Co.

PIPE, RUBBER-LINED

Farris Flexible Valve Corp.—"FLEXVALVE," "SUPER SEAL"
Galigher Co.
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Goodyear Tire & Rubber Co.
Industrial Rubber Products Co. (Pa.)
Naylor Pipe Co.
Raybestos Manhattan, Inc., Manhattan Rubber Div.—"CONDOR"
United States Rubber Co.

PIPE, SEAMLESS

Phoenix Iron & Steel Co.

PIPE, SLUDGE

Naylor Pipe Co.

PIPE, SPIRAL-WELDED

Armco Drainage & Metal Prod. Inc.
L. B. Foster Co.
Midland Pipe & Supply Co.
Naylor Pipe Co.

PIPE, STAINLESS STEEL

Allegheny Ludlum Steel Corp.
Crucible Steel Co. of America.
National Tube Div., United States Steel Corp.—"USS"

PIPE, STEEL

Armco Drainage & Metal Prod., Inc.
Bethlehem Steel Co.

A-W Hydraulic Crane speeds repairs on giant shovel at Bagdad Copper Corp., Bagdad, Arizona. It also saves many costly man-hours on a host of other lifting jobs. The maintenance superintendent calls it the "handiest darn machine around here."

AUSTIN-WESTERN... speeds production, reduces downtime

A-W Hydraulic Crane saves maintenance man-hours

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A-W Power Grader at work in open pit mine of Midland Electric Coal Co. at Farmington, Illinois

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A-W Power Graders with all-wheel drive give you 30% more power where it counts—at the blade. In addition, this extra tractive power lets you grade access and haul roads where other machines would be hopelessly bogged down. All-wheel steer allows extreme maneuverability. Because of its power and stamina, an A-W equipped with a bulldozer attachment often saves the cost of a tractor-bulldozer.

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National Supply Company — "SPANG"
National Tube Div., United States Steel Corp.—"USS NATIONAL"
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Youngstown Sheet & Tube Co. —"YOLOY"

PIPE, STEEL WELDED

Armco Drainage & Metal Prod., Inc.
Bethlehem Steel Co.
L. B. Foster Co.
Jones & Laughlin Steel Corp.
L. O. Koven & Bro., Inc.
National Tube Div., United States Steel Corp.—"USS NATIONAL"
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Youngstown Sheet & Tube Co.

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Peter O. Sutphen

PIPE, WOOD-STAVE

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Fluor Products Co.

PIPE, WROUGHT-IRON

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Midland Pipe & Supply Co.
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PIPE COUPLINGS

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PIPE FITTINGS, NYLON

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PIPE FITTINGS, PLASTIC

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Franklin Plastics Inc. — "DUR-X"
B. F. Goodrich Industrial Products Co.—"KOROSEAL"
Grinnell Co.
Johnson Plastic Corp.
Midland Pipe & Supply Co.
National Mine Service Co.
Republic Steel—"REPUBLIC"
Triangle Conduit & Cable Co., Inc.
United States Rubber Co.
Walworth Co.
Youngstown Sheet & Tube Co.

PIPE FITTINGS, RUBBER

United States Rubber Co.

PIPE FITTINGS, STAINLESS-STEEL

Electric Steel Foundry Co.

PIPE FITTINGS, STEEL & ALLOYS

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PIPE FITTINGS, WROUGHT-IRON

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PIPE FLANGES, FORGED, STAINLESS

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PLANERS

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Mining Progress, Inc.

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Republic Steel—"REPUBLIC"
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Youngstown Sheet & Tube Co.

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PLATE, FLOOR

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Kanawha Mfg. Co.

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A. M. Byers Co.
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Crucible Steel Co. of America
The Daniels Co., Contractors, Inc.
Guyan Machy. Co.
Robert Holmes & Bros., Inc
Jones & Laughlin Steel Corp
Kanawha Mfg. Co
Phoenix Iron & Steel Co
W. J. Savage Co
Stulz-Sickles Co.—"Man-GANAL"
United States Steel Corp.
Youngstown Sheet & Tube Co.

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Elliott Service Co., Inc.

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Hercules Powder Co.
King Powder Co., Inc.
National Powder Co.
Olin-Mathieson Chemical Corp., Explosives Div.

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Westinghouse Electric Corp.

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Denison Engrg. Div., American Brake Shoe Co.
Vickers Inc.
Vickers, Inc., Tulsa Winch Div.

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Industrial Engrg. & Construction Co., Inc.
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Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Southwestern Engineering Co.
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Blackhawk Mfg. Co.
Templeton, Kenly & Co.—"RE-MO-TROL"

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Hewitt-Robins Incorporated
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McLanahan & Stone Corp.
Transall, Inc.
Webster Mfg., Inc.
T. B. Woods Sons Co.

PULLEYS, CONVEYOR — SEE Conveyors, Belt Idlers, Conveyor-Belt Idler Pulleys

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Reeves Pulley Co., Div. The Reliance Electric & Engrg. Co.—"VARI-SPEED"

PULLEYS, PAPER
Browning Mfg. Co.

PULLEYS, RUBBER-COVERED
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PULLYS, SEMI-STEEL
Continental Gin Co., Ind. Div.
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58
McLanahan & Stone Corp.
Webster Mfg., Inc.
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Bonded Scale & Machine Co.—"BONDED"
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"TAPER-LOCK"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
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Meckum Engr. Co.
W. J. Savage Co.
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Hardinge Co., Inc.

PULVERIZERS, FURNACE-FEED
Combustion Engineering, Inc.—"C-E-RAYMOND"
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Gruendler Crusher & Pulverizer Co.
Jeffrey Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Majac Inc., Sub. of Blackstone Corp.
Williams Patent Crusher & Pulv. Co.

PULVERIZERS, LABORATORY
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Combustion Engineering, Inc.—"C-E-RAYMOND"
Fisher Scientific Co.
Gruendler Crusher & Pulverizer Co.
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Sturtevant Mill Co.
Universal Engineering Corp.
Williams Patent Crusher & Pulv. Co.

PUMPING STATIONS
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PUMP-PRIMING EQUIPMENT
Barrett, Haentjens & Co.
Flood City Brass & Electric Co.
Goyne Pump Co.
Nash Engineering Co.

PUMPS, AIR-DRIVEN
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M. Glosser & Sons Inc.

PUMPS, AIR-HYDRAULIC
Ledeen Mfg. Co.

PUMPS, ASH (WATER JET)
Canton Stoker Corp.—"WAGENER"

PUMPS, CENTRIFUGAL
Allen-Sherman-Hoff Pump Co.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Brake Shoe Co., Amsco Div.—"AMSCO"
American-Marsh Pumps, Inc.
American Well Works
Ampco Metal, Inc.
Aurora Pump Div., The New York Air Brake Co.
Barnes Mfg. Co.
Barrett, Haentjens & Co.
Buffalo Forge Co.
Byron Jackson Pumps, Inc., A Sub. of Borg-Warner Corp.
Carver Pump Co.
Chain Belt Co.—"REX"
Construction Machy. Co.
Dean Brothers Pumps Inc.
The Deming Co.
Dorr-Oliver, Inc.
The Duriron Co., Inc.
Emglo Products Corp.—"EMGLO"
Ensign Electric & Mfg. Co.
Flood City Brass & Electric Co.
Gardner-Denver Company
M. Glosser & Sons, Inc.
The Gorman-Rupp Co.
Goulds Pumps, Inc.
Goyne Pump Co.
Guyan Machy. Co.—"GORMAN RUPP," "MYERS"
Homelite, Div. Textron Inc.—"HOMELITE"
Ingersoll-Rand Co.
LaBour Co., Inc.
Lancaster Pump & Mfg. Co.—"UNIT PUMP TYPE M"
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McNally-Pittsburg Mfg. Corp.
Morris Machine Works
Nagle Pumps, Inc.
National Mine Service Co.
Peerless Pump Div., Food Machinery & Chemical Corp.,
Pennsylvania Pump & Compressor Co.—"THRUSTFRE"
Rice Pump & Machine Co.
Roots-Connersville Blower, Div. Dresser Industries Inc.
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PUMPS, CENTRIFUGAL REBUILT
Leman Machine Co.

PUMPS, CENTRIFUGAL SELF-PRIMING
American Well Works
Aurora Pump Div., The New York Air Brake Co.
Barnes Mfg. Co.
Byron Jackson Pumps, Inc., A Sub. of Borg-Warner Corp.
Carver Pump Co.
Chain Belt Co.—"REX"
Chicago Pneumatic Tool Co.
Construction Machy. Co.
The Deming Co.
The Duriron Co., Inc.
Ensign Electric & Mfg. Co.
The Gorman-Rupp Co.
Goulds Pumps, Inc.
Guyan Machy. Co.—"GORMAN RUPP"
Homelite, Div. Textron Inc.—"HOMELITE"
Ingersoll-Rand Co.
LaBour Co., Inc.—"HYDRO-BALANCE"
Lancaster Pump & Mfg. Co.
Marlow Pumps, Div. of Bell & Gossett Co.
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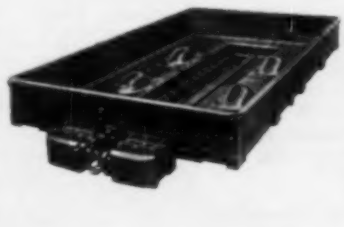

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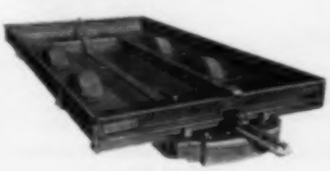

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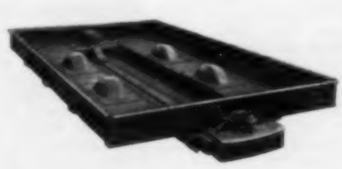

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Your insurance against haulage delays and shut-downs . . .
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Eimco Corp.
Gardner-Denver Company
The Gorman-Rupp Co.
Homelite, Div. Textron Inc.—"HOMELITE"
Guyan Machy. Co.—"GORMAN RUPP"
Marlow Pumps, Div. of Bell & Gossett Co.
Morse Bros. Machinery Co.
Ore Reclamation Co.
Rice Pump & Machine Co.
Western Machinery Co.—"WEMCO"
Worthington Corp.

PUMPS, DRUM

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Gray Co., Inc.—"DIRECT-FROM-DRUM"
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.—"AIRLINE"

PUMPS, FIRE

Flood City Brass & Electric Co.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Layne & Bowler Pump Co.—"VERTI-LINE"
Porto Pump, Inc.

PUMPS, FROTH HANDLING

Denver Equipment Co.—"DEN-VER"

PUMPS, HIGH PRESSURE

Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.

PUMPS, HIGH VACUUM

Central Scientific Co.—"CEN-CO HYVAC"

PUMPS, HORIZONTAL-SHAFT

Nagle Pumps, Inc.—"TYPE-H"

PUMPS, JET

Aurora Pump Div., The New York Air Brake Co.
Barnes Mfg. Co.
Construction Machy. Co.
The Deming Co.
The Gorman-Rupp Co.
Goulds Pumps, Inc.
Ingersoll-Rand Co.
Lancaster Pump & Mfg. Co.—"DUTCHMAN"
Porto Pump, Inc.

PUMPS, METERING

B-I-F Industries, Inc.
Roots-Connersville Blower, Div. Dresser Industries Inc.

PUMPS, OIL

Canton Stoker Corp.—"WAG-ENER"

PUMPS, PISTON & PLUNGER

American-Marsh Pumps, Inc.
Canton Stoker Corp.—"WAG-ENER"
Dean Brothers Pumps Inc.
The Deming Co.
Flood City Brass & Electric Co.
Gardner-Denver Company
Goulds Pumps, Inc.
Guyan Machy. Co.—"MYERS"
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Co.
Lancaster Pump & Mfg. Co.—"GIANT," "LITTLE GIANT"
Ledeen Mfg. Co.
National Mine Service Co.
National Supply Company—"NATIONAL"
Worthington Corp.

PUMPS, PLUNGER

Aldrich Pump Co.

PUMPS, PORTABLE SLUDGE AIR

Herold Mfg. Co.

PUMPS, PRESSURE-TESTING

Porto Pump Inc.

PUMPS, PRIMING

American Crucible Products Co., Kenco Pump Div.

PUMPS, RADIAL PISTON

American Engineering Co.—"HELE-SHAW," "HYRA-MITE"

PUMPS, ROTARY

The Deming Co.

PUMPS, ROTARY PISTON GEAR

Kinney Mfg. Div., The New York Air Brake Co.

PUMPS, SAND ABRASIVE HANDLING

Denver Equipment Co.—"DEN-VER S-R-L"

PUMPS, SOLIDS-HANDLING

Allen-Sherman-Hoff Pump Co.—"HYDROSEAL-CENTRI-SEAL"
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Brake Shoe Co., Amsco Div.—"AMSCO"
American-Marsh Pumps, Inc.
Aurora Pump Div., The New York Air Brake Co.
Barnes Mfg. Co.
Barrett, Haentjens & Co.
Canton Stoker Corp.—"WAGENER"
The Deming Co.
Dorr-Oliver, Inc.
Galigher Co.—"VACSEAL"
Gardner-Denver Company
Goulds Pumps, Inc.
Goyne Pump Co.
Guyan Machy. Co.—"WEMCO"
Linatex Corp. of America
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.
Marlow Pumps, Div. of Bell & Gossett Co.
Meckum Engr. Co.
Morris Machine Works
Nagle Pumps, Inc.
Ore Reclamation Co.
Robbins & Myers, Inc.—"MOY-NO"
Western Machinery Co.—"WEMCO TORQUE FLOW"
A. R. Wilfley & Sons
Worthington Corp.

PUMPS, SLURRY

Morris Machine Works

PUMPS, SPRAY, HIGH-PRESSURE

Flood City Brass & Electric Co.

PUMPS, SUBMERSIBLE

American Crucible Products Co., Kenco Pump Div.
Byron Jackson Pumps, Inc., A Sub of Borg-Warner Corp.
The Deming Co.
Guyan Machy. Co.—"REDA"
Lancaster Pump & Mfg. Co.—"EMU"

PUMPS, SUMP

Allen-Sherman-Hoff Pump Co.—"HYDROSEAL"
Allis-Chalmers Mfg. Co, Industrial Equipment Div.
American Crucible Products Co., Kenco Pump Div.
American-Marsh Pumps, Inc.
Aurora Pump Div., The New York Air Brake Co.
Barnes Mfg. Co.
Barrett, Haentjens & Co.
Buffalo Forge Co.
Byron Jackson Pumps, Inc., A Sub. of Borg-Warner Corp.
Chicago Pneumatic Tool Co.
The Deming Co.
Emglo Products Corp.—"EMGLO"
Flood City Brass & Electric Co.
Galigher Co.—"GALIGHER"
Gardner-Denver Company
M. Glosser & Sons Inc.
The Gorman-Rupp Co.
Goulds Pumps, Inc.
Ingersoll-Rand Co.
Johnston Pump Co., Div. of Youngstown Sheet and Tube Co.
Lancaster Pump & Mfg. Co.
Layne & Bowler Pump Co.—"VERTI-LINE"
Le Roi Div., Westinghouse Air Brake Co.
Marlow Pumps, Div. of Bell & Gossett Co.
Morris Machine Works
Nagle Pumps, Inc.
Peerless Pump Div., Food Machinery & Chemical Corp.
Penn Machine Co.
Robbins & Myers, Inc.—"MOYNO"
Schramm, Inc.
Thor Power Tool Co.
Worthington Corp.

PUMPS, VACUUM

Canton Stoker Corp.—"WAGENER"
Joy Mfg. Co.
Kinney Manufacturing Div., The New York Air Brake Co.
Nash Engineering Co.

PUMPS, VARIABLE DELIVERY

Nathan Mfg. Corp.

PUMPS, VERTICAL, CENTRIFUGAL

Barrett, Haentjens & Co.
Buffalo Forge Co.
Dean Brothers Pumps Inc.
Gorman Rupp Co.
Lancaster Pump & Mfg. Co., Inc.
Morris Machine Works
Nagle Pumps, Inc.

PUMPS, VERTICAL, CENTRIFUGAL AND TURBINE

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Well Works
Aurora Pump Div., The New York Air Brake Co.
Byron Jackson Pumps, Inc. A Sub. of Borg-Warner Corp.
The Deming Co.
Ensign Electric & Mfg. Co.
Goulds Pumps, Inc.
Ingersoll-Rand Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery & Chemical Corp.
Pennsylvania Drilling Co.
Worthington Corp.

PUMPS, VERTICAL, TURBINE,

Johnston Pump Co., Div. of The Youngstown Sheet & Tube Co.

PUSHBUTTONS

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Clark Controller Co.
Crouse-Hinds Co.
Cutler-Hammer, Inc.—"ROTO-PUSH"
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
Mosebach Electric & Supply Co.
Westinghouse Electric Corp.

PYROMETERS

The Bristol Co.—"BRISTOL'S"
Fisher Scientific Co.
Foxboro Co.
General Electric Co., Apparatus Sales Div.
Minneapolis-Honeywell Regulator Co., Industrial Division—"ELECTRONIK"
West Instrument Corp.—"GARDSMAN-VERI-TELL"

RADIO SYSTEMS

General Electric Co., Communication Products Dept.
Mine Safety Appliances Co. "MINE PHONE"
Motorola Communications & Electronics, Inc.

RAIL

Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
L. B. Foster Co.
M. Glosser & Sons Inc.
Morse Bros. Machinery Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIR-GINIA"
United States Steel Corp.

RAIL BENDERS

The Aldon Co.
Duquesne Mine Supply Co.
L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.—"GEMCO TRU-BLU"
National Mine Service Co.
Utility Mine Equipment Co.—"UMECO"
Watt Car & Wheel Co.

RAIL BOLTS

Bethlehem Steel Co.
Colorado Fuel & Iron Corp.—"C F & I"
L. B. Foster Co.
Morse Bros. Machinery Co.
Pittsburgh Screw & Bolt Corp.

RAIL-BOND TERMINALS

American Mine Door Co.

RAIL BONDS

American Steel & Wire—"TIGERWELD," "TIGER-BRAZE"
Copperweld Steel Co.—"COP-PERWELD"
Ensign Electric & Mfg. Co.
Erico Products, Inc.—"CAD-WELD"
Flood City Brass & Electric Co.
Mosebach Electric & Supply Co.
National Mine Service Co.
Ohio Brass Co.
Penn Machine Co.—"EVER-LAST SUPER-WELD"
Schroeder Brothers Corp.

RAIL BRACES

L. B. Foster Co.
The Nolan Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIR-GINIA"

RAIL CLAMPS

Dravo Corp.
Duquesne Mine Supply Co.
L. B. Foster Co.
Mosebach Electric & Supply Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIR-GINIA"

RAIL CONTACT DEVICES

Nachod & U. S. Signal Co.

RAIL CROSSINGS, RUBBER

Goodyear Tire & Rubber Co.

RAIL DOLLIES

Templeton, Kenly & Co.—"SIMPLEX"

RAIL DRILLS

L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.
Nordberg Mfg. Co.
Ohio Brass Co.

RAIL FROGS

Bethlehem Steel Co.
C. S. Card Iron Works
L. B. Foster Co.
Helmick Foundry-Machine Co.
Morse Bros. Machinery Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

RAIL GRINDERS

Nordberg Mfg. Co.

RAIL PUNCHES

L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.—"GEMCO TRU-BLU"
Mine Safety Appliances Co.—"VELOCITY-POWER"
National Mine Service Co.
Utility Mine Equipment Co.—"UMECO"

RAIL SIGNAL SYSTEMS, MANUAL & AUTOMATIC

American Mine Door Co.
Nachod & U. S. Signal Co.

RAIL SPIKE DRIVERS

American Brake Shoe Co., Railroad Products Div.

RAIL SPIKES

Bethlehem Stel Co.
Colorado Fuel & Iron Corp. "C F & I"
L. B. Foster Co.
Morse Bros. Machinery Co.
Youngstown Sheet & Tube Co.

RAIL SPLICE BARS, PLATES

Bethlehem Steel Co.
Colorado Fuel & Iron Corp.—"C F & I"
L. B. Foster Co.
Morse Bros. Machinery Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

RAIL SPRING-SWITCH SNUBBERS

Cheatham Elec. Switching Device Co.

RAIL SWITCH-POSITION INDICATORS

American Mine Door Co.
Cheatham Elec. Switching Device Co.
L. B. Foster Co.
Joy Mfg. Co.
Miners' Hardware Supply Co.

RAIL SWITCHES, AUTOMATIC

The Nolan Co.

RAIL SWITCHTHROWERS

Union Switch & Signal Div. Westinghouse Air Brake Co.

RAIL SWITCHTHROWERS, AIR, AUTOMATIC

American Mine Door Co.—"AERO-THROW"

RAIL SWITCHTHROWERS, ELECTRIC, AUTOMATIC

American Mine Door Co.—"ELECTRI-THROW"
Cheatham Elec. Switching Device Co.
L. B. Foster Co.
Joy Mfg. Co.

RAIL TIE HOLDERS

The Leetonia Tool Co.

RAIL TIE PLATES

Bethlehem Steel Co.
L. B. Foster Co.
Morse Bros. Machinery Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"
United States Steel Corp.

RAIL TIES, PRESERVATIVE TREATED, UNTREATED

T. J. Moss Tie Co.

RAIL TIES, STEEL

Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
L. B. Foster Co.
National Mine Service Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

RAIL TRACK SUPPLIES

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H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

RAIL WELDING MATERIALS

American Brake Shoe Co., Amsco Div.—"AMSCO"

RAILS, GUARD

H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

RAILS, TRANSITION

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General Electric Co., Apparatus Sales Div.

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American Alloy Corp.

RECORDERS, TEMPERATURE

West Instrument Corp.—"MARKSMAN"

REAR DUMPERS, SELF-PROPELLED

Continental Copper & Steel Industries, Inc., Wooldridge Div.—"CONTINENTAL WOOLDRIDGE"

RECTIFIERS, COPPER-OXIDE

Union Switch & Signal, Div. of Westinghouse Air Brake Co.

RECTIFIERS, GERMANIUM

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Perkin Engineering Corp.

RECTIFIERS, MERCURY-ARC

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"EXCITRON"
General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
Hackbridge & Hewittic Electric Co., Ltd.
Herbert S. Littlewood
Wesinghouse Electric Corp.

RECTIFIERS, MECHANICAL

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RECTIFIERS, SELENIUM

General Electric Co., Apparatus Sales Div.
General Nuclear Corp.
Perkin Engineering Corp.
Syntron Co.
Westinghouse Electric Corp.

RECTIFIERS, SILICON

I-T-E Circuit Breaker Co.
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REDUCTION GEARS, INDUSTRIAL, ENGINE INSTALLATION

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Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co.—"LUB-REELS"

REFRACTORIES

Bigelow-Liptak Corp.
Philip Carey Mfg. Co.
Corhart Refractories Co.
Joseph Dixon Crucible Co.
Johns-Manville—"FIRECRETE," "BLAZE-CRETE," "HELLITE," "FIREITE"
Norton Co.—"ALUNDUM," "CRYSTOLON," "MAGNORITE"
Mexico Refractories Co.

REFRACTORIES, ABRASION-RESISTANT

Corhart Refractories Co.—"CORHART ZAC ELECTRO-CAST REFRACTORY"

REFRACTORIES, CASTIBLE

Mexico Refractories Co.—"FURNAS-CRETE," "HI-STRENGTH F-303-S," "I-R-C," "I-R-C 20," "MEXICAST," "MILL-CRETE," "PUROCAST 3000," "PURO-

TAB," "SAKONITE," "LO-ERODE," "ACITAB"

REFRACTORIES, CHROME

Mexico Refractories Co. —"CHROME CONCRETE," "HILO-CHROME," "MONO-CHROME," "SUPER CHROME CONCRETE"

REFRACTORIES, GRAPHITE

Mexico Refractories Co.—"HEL-SPOT," "HELSKOTE," "STULKOTE"

REFRACTORIES, PLASTIC

Mexico Refractories Co.— "MAX BOND," "MONO-FIBRIK," "SUPER MONO-FIBRIK T-9"

REGULATORS, DRAFT

The Bristol Co.—"BRISTOL'S"
A. W. Cash Co.
Hays Corp.
Minneapolis-Honeywell Regulator Co., Industrial Division

REGULATORS, ELECTRIC CONTROL

Cutler-Hammer, Inc.

REGULATORS, PRESSURE

The Bristol Co.—"BRISTOL'S"
A. W. Cash Co.
A. W. Cash Valve Mfg. Corp.
Fischer & Porter Co.
Hauck Mfg. Co.
Hays Corp.
Minneapolis-Honeywell Regulator Co., Industrial Division
Rockwell Mfg. Co.

REGULATORS, TEMPERATURE

The Bristol Co.—"BRISTOL'S"
A. W. Cash Co.
Fischer & Porter Co.
Hays Corp.
Minneapolis-Honeywell Regulator Co., Industrial Division
West Instrument Corp.— "GARDSMAN"

REGULATORS, VOLTAGE

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Clark Controller Co.
Electric Machinery Mfg. Co.
General Electric Co., Apparatus Sales Div.
Perkin Engineering Corp.
Westinghouse Electric Corp.

RELAYS, ELECTRIC

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
American Mine Door Co.
Cheatham Elec. Switching Device Co.
Clark Controller Co.
Cutler-Hammer, Inc.
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
Joy Mfg. Co.
Nachod & U. S. Signal Co.
Westinghouse Electric Corp.

RELAYS, HERMETICALLY SEALED

Union Switch & Signal Div. of Westinghouse Air Brake Co.

RELAYS, MERCURY

Durakool, Inc.
Joy Mfg. Co.
Mining Machine Parts Inc.

RELAYS, MINIATURE

Union Switch & Signal Div. Westinghouse Air Brake Co.

RELAYS, PNEUMATIC TIME DELAY

Elastic Stop Nut Corp. of America—"AGASTAT"

RELAYS, ROTARY

Union Switch & Signal Div. of Westinghouse Air Brake Co.

RELAYS, SENSITIVE

Union Switch & Signal Div. of Westinghouse Air Brake Co.

REMOTE CONTROL SYSTEMS

Taller & Cooper, a Sub. of American Electronics, Inc.

REPAIR SERVICE, MINE EQUIPMENT

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National Electric Coil Co.
W. J. Savage Co.
Simplicity Engineering Co.

REPRODUCTION EQUIPMENT

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RERAILERS

The Aldon Co.
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Duquesne Mine Supply Co.
L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.
Miners Hardware Supply Co.
The Nolan Co.
Sanford Day Iron Works, Inc.

RESINS, IMPREGNATING

Minnesota Mining & Mfg. Co. —"SCOTCHCAST"

RESISTORS

Clark Controller Co.
Cutler-Hammer, Inc.
Ensign Electric & Mfg. Co.
General Electric Co., Apparatus Sales Div.
Guyan Machy. Co.—"GUYAN"
Jeffrey Mfg. Co.
Joy Mfg. Co.
Keystone Carbon Co.—"NTC"
Mosebach Electric & Supply Co.
National Mine Service Co.
Ohio Carbon Co.—"OHIOHM"
Penn Machine Co.
The Post Glover Electric Co.—"P-G STEEL GRID"
Stackpole Carbon Co.
Westinghouse Electric Crop.

RESPIRATORS

American Optical Co., Safety Products Div.
E. D. Bullard Co.
Chicago Eye Shield Co.
Fisher Scientific Co.
General Scientific Equipment Co.—"GS"
Martindale Electric Co.
Mine Safety Appliances Co.—"COMFO," "DUSTFOE," "GASFOE"
Pulmosan Safety Equip. Co.
United States Rubber Co.

RETAINERS, BEARING

Bearings, Inc.
Link-Belt Co., Dept. CAMGL-58

RHEOSTATS

American Cyanamid Co., Explosives and Mining Chemicals Dept.
Central Scientific Co.
Clark Controller Co.
Cutler-Hammer, Inc.
General Electric Co., Apparatus Sales Div.
Hercules Powder Co.
National Powder Co.
Westinghouse Electric Corp.

RIFFLE BUCKETS

Instrument Div., Gichner Inc.

RINGS, COLLECTOR, ARMATURE

Superior Carbon Products, Inc.
West Virginia Armature Co.

RIPPERS, BULLDOZERS, FRONT-MOUNTED

H & L Tooth Co.

RIPPERS, CABLE-CONTROLLED

Continental Copper & Steel Industries, Inc., Wooldridge Div.

RIPPERS, HYDRAULIC

Tractomotive Corp.—"TRACTORIPPER"

RIVER-LOADING PLANTS

Fairmont Machinery Co.
Heyl & Patterson, Inc.
Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

RIVETS

Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Republic Steel—"REPUBLIC"

ROCK-DUST DISTRIBUTORS, DRY

American Mine Door Co.—"DUSTMASTER, MIGHTY MIDGET," "LITTLE CHIEF"
Imperial-Cantrell Mfg. Co.—"JET"
Mine Safety Appliances Co.—"BANTAM," "BANTAM 400," "TYPE S"

ROCK-DUST DISTRIBUTORS, WET

American Mine Door Co.—"LITTLE CHIEF"
Central Mine Supply Co. Div. Pickard Industries Inc.—"NO DUST"
Mine Safety Appliances Co.—"BANTAM 400 SLURRY TYPE"

RODS, LEVELING AND STADIA

Kern Instruments, Inc.

ROLLERS, CAST-IRON

Link-Belt Co., Dept. CAMGL-58
Webster Mfg., Inc.

ROLLERS, ROAD

Austin-Western, Construction Equipment Div., Baldwin-Lima-Hamilton Corp.
Blaw-Knox Co.
Galion Iron Works & Mfg. Co.
Huber-Warco Co.—"HUBER-WARCO"

ROLLERS, SLOPE, CAST IRON, STEEL

C. S. Card Iron Works
Robert Holmes & Bros., Inc.
Kanawha Mfg. Co.
Sanford Day Iron Works, Inc.

ROLLERS, SLOPE, WOOD

C. S. Card Iron Works
J. V. Hammond Co.

ROOF ARCHES, STEEL

Arrowhead Constructors and Engineers, Inc.
Mining Progress, Inc.

ROOF BARS, ALUMINUM

Reynolds Metals Co.

ROOF BARS, ALUMINUM HINGED

Herold Mfg. Co.

ROOF BARS, STEEL

Mining Progress, Inc.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"

ROOF BARS, STEEL HINGED

Herold Mfg. Co.

ROOF-BOLT HOLE GAGES

Ohio Brass Co.

ROOF-BOLT PULLERS, HYDRAULIC

Continental Gin Co., Ind. Div.

ROOF-BOLT TENSION INDICATORS

American Mine Supply Co.
Coninental Gin Co., Ind. Div.
Herold Mfg. Co.
Snap-on Tools Corp.

ROOF BOLT EXPANSION SHELLS

National Mine Service Co.
Ohio Brass Co.
Valve Div., Thompson Products, Inc.—"TOP-TITE"

ROOF BOLTING, EXPANSION-SHELL

American Bridge Div., U. S. Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.—"C F & I"
National Mine Service Co.
Pattin Mfg. Co.
Pittsburgh Screw & Bolt Corp.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"
Republic Steel—"REPUBLIC"
Valve Div., Thompson Products, Inc.—"TOP-TITE"
Youngstown Sheet & Tube Co.

ROOF BOLTS, MORTAR EMBEDMENT

Sika Chemical Corp.—"PERFO SYSTEM"

ROOF BOLTS, SQUARE HEAD

Sheffield Div., Armco Steel Corp.

ROOF BOLTS, SUSPENSION-ARM

H. K. Porter Co., Connors Steel Div.

ROOF BOLTS, WEDGE-TYPE

American Bridge Div., U. S. Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.—"C F & I"
National Mine Service Co.
Pattin Mfg. Co.
H. K. Porter Co., Connors Steel Div.—"WEST VIRGINIA"
Republic Steel—"REPUBLIC"
Youngstown Sheet & Tube Co.

ROOF DRAINS

J. A. Zurn Mfg. Div., Zurn Industries, Inc. — "ZURN"

ROOF RESURFACERS

Stonhard Co.

ROOF SUPPORTS, ALUMINUM

Reynolds Metals Co.

ROOF SUPPORTS, YIELDABLE ARCH

Bethlehem Steel Co.
Herold Mfg. Co.
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ROOF SUPPORTS, YIELDING MINE PROPS

Herold Mfg. Co.
Mining Progress, Inc.

ROOF VENTILATORS, POWER

American Blower, Div. of American-Standard

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Revere Copper & Brass Inc.

ROOFING, FLASHING, NICKEL ALLOY

International Nickel Co., Inc.

ROOFING, FLASHING-ZINC

Illinois Zinc Co.

ROOFING, SIDING, ALUMINUM

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T. J. Moss Tie Co.
Revere Copper & Brass Inc.
Reynolds Metals Co.

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Philip Carey Mfg. Co.—"4.2 CAREYSTONE"
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Keasbey & Mattison Co.
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ROOFING, SIDING, ASPHALT

The Ruberoid Co.

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Arrowhead Constructors & Engineers, Inc.
Bethlehem Steel Co.
T. J. Moss Tie Co.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
United States Steel Corp.

ROOFING, SIDING, ZINC

Illinois Zinc Co.

ROOTERS

LeTourneau-Westinghouse Co.

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General Logistics—"ROPE-LOCK"

RUBBER, SILICONE

Dow Corning Corp.—"SILASTIC"

RUST PREVENTATIVE COMPOUNDS

American Minechem Co.—"CHEMPENT"

SAFETY BELTS

E. D. Bullard Co.—"MORENCI"
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.

SAFETY DISPLAYS, SIGNS

Elliott Service Co., Inc.
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.—"M-S-A"

SAFETY EQUIPMENT

Mine Safety Appliances Co.

SAFETY FOOTGEAR, LEATHER

Hy-Test Safety Shoe Div., International Shoe Co.—"HY-TEST"
Mine Safety Appliances Co.

SAFETY FOOTGEAR, RUBBER

Goodall Rubber Co.
Mine Safety Appliances Co.

SAFETY HEADGEAR

American Optical Co.
E. D. Bullard Co.—"HARD-BOILED"
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.—"SKULL-GARD," "COMFO CAP"
National Mine Service Co.
Pulmosan Safety Equip. Co.
United States Safety Service Co.—"SAFHED"

SAFETY HOOKS

E. D. Bullard Co.—"BULLARD-BURNHAM"
Coffing Hoist Div., Duff-Norton Co.
Crosby Laughlin Div. American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
General Scientific Equipment Co.—"GS"

SAFETY SIGNS REFLECTORIZED

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SALT

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Morton Salt Co.—"MORTON"

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Builders of Centrifugal Pumps and Hydraulic Dredges Since 1864

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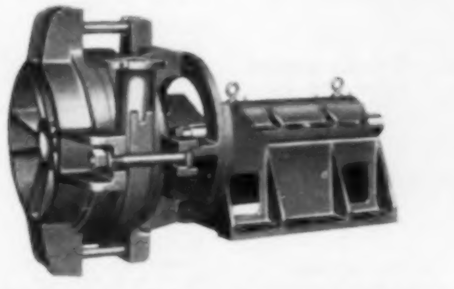

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. . . for continuous 24-hour pumping of **Ore Slurries, Tailings, Concentrates, Abrasive Mixtures.**

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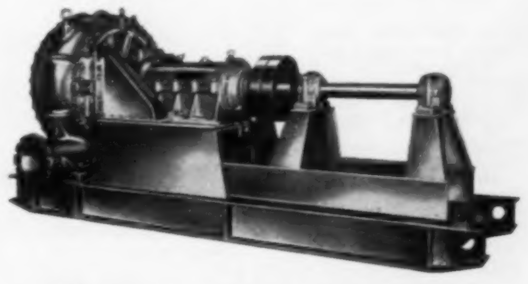
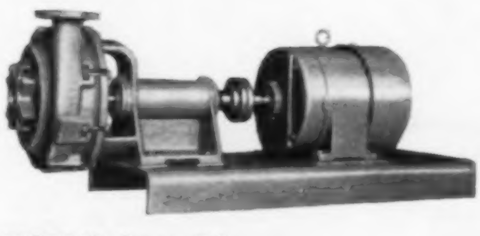


MORRIS type "GA" and "GAF" HEAVY DUTY DREDGE PUMPS

Small high speed or large low speed units for pumping abrasives against high heads.

- **Giant shaft** of high-grade steel withstands vibration, handles shock loads easily.
- **Suction opening** is larger than discharge for handling higher percentage of solids at greater depths without excessive vacuum on suction.
- **Oversize antifriction bearing assembly.**
- **Economical impeller design.** With external cleaning vanes on both sides. Enlarged suction shroud seals on nose.
- **Heavy volute casing** with extra heavy sections at points of maximum wear. Discs covered with heavy renewable liners . . . openings are of same size for right or left hand assembly.

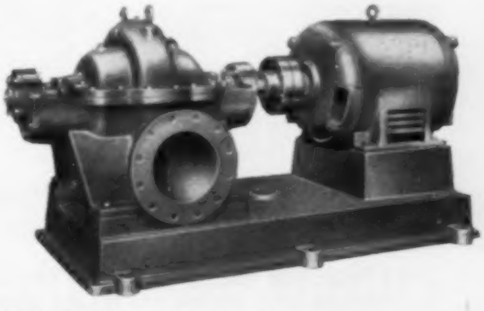
Wearing parts furnished in special alloys. Sizes: 6" to 36". Send for Bulletin No. 184.



MORRIS Type BA Slurry Pump

For continuous 24-hour duty in abrasive process handling.

- **Small, high-speed slurry pump** with built-in abrasive resistance.
- **Available in cast-iron,** Ni-hard, or 316 stainless steel.
- **Features renewable suction liner** and semi-open impeller.
- **Simple design,** rugged construction, easy to dismantle and re-assemble.
- **Sizes** range from 1" to 4".



MORRIS Double-Suction Horizontally-Split Centrifugal Pump

For Drainage and General Service

- **Floating Sealing Rings** adjust concentrically to impeller speeds.
- **Extra-heavy shaft** of tough, hard alloy steel.
- **Upper part** of horizontally-split casing easily removed without disturbing suction or discharge piping.
- **Heavy-duty, precision ball bearings** mounted in dust- and moisture-proof housings.

May be connected in series for higher heads. Sizes: 2" to 220". Send for Bulletin No. 179.

SALT, ROCK
International Salt Co.—"STERLING" "STERLING INHIBIUM TREATED"

SALT, STERLING
International Salt Co.—INHIBIUM TREATED"

SALT, WITH RUST INHIBITOR
Diamond Crystal Salt Co.

SALT TABLETS
E. D. Bullard Co.
Morton Salt Co.—"MORTON"
Pulmosan Safety Equip. Co.
United States Safety Service Co.—"PEP-UP"

SAMPLERS, COAL,
Denver Equipment Co.—"DENVER"
Fisher Scientific Co.
Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
Mobile Drilling, Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Sturtevant Mill Co.

SAMPLERS, COAL, AUTOMATIC
Colorado Iron Works Co., A Sub of Mine & Smelter Supply Co.—"VEZIN"
Denver Equipment Co.—"DECO"
Galigher Co.—'GEARY JENNINGS"
Hardinge Co., Inc.
Heyl & Patterson, Inc.
Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburgh Mfg. Corp.
Sturtevant Mill Co.

SAND DRIERS
Barber-Greene Co.
J. D. Christian Engineers
Cowanesque Valley Iron Works—"SUTTON"
Denver Equipment Co.
Eimco Corp.
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Joy Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Pioneer Engineering, Div. of Poor & Co.

SANDERS, PORTABLE ELECTRIC
Black & Decker Mfg. Co.

SAW BLADES
Gensco Tools Div., General Steel Warehouse Co., Inc.
Disston Div., H. K. Porter Co., Inc.
Martindale Electric Co.
Simonds Saw & Steel Co.—"SI-CLONE," "RED CENTER"

SAWS, BAND
Simonds Saw & Steel Co.

SAWS, BOW
Gensco Tools Div., General Steel Warehouse Co., Inc.

SAWS, CARBIDE-TIPPED
Simonds Saw and Steel Co.

SAWS, CIRCULAR
Black & Decker Mfg. Co.
Martindale Electric Co.
Simonds Saw & Steel Co.—"RED CENTER"

SAWS, HACK
Disston Div., H. K. Porter Co., Inc.
Simonds Saw & Steel Co.
Snap-on Tools Corp.

SAWS, HAND
Disston Div., H. K. Porter Co., Inc.
Gensco Tools Div., General Steel Warehouse Co., Inc.

SAWS, METAL CUTTING
Simonds Saw and Steel Co.

SAWS, MINE & UTILITY
Disston Div., H. K. Porter Co., Inc.

SAWS, PORTABLE AIR
Herold Mfg. Co.
Homelite, Div. Textron Inc.

SAWS, PORTABLE ELECTRIC
Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
Homelite, Div. Textron Inc.
Syntron Co.
Thor Power Tool Co.

SAWS, PORTABLE GASOLINE
Homelite, Div., Textron Inc.
Lancaster Pumps & Mfg. Co., Inc.

SAWS, POWER
Thor Power Tool Co.

SAWS, POWER, AIR
Ingersoll-Rand Co.

SAWS, RECIPROCATING BLADE, AIR, GASOLINE
Wright Power Saw & Tool Corp.

SCALE-WEIGHT RECORDERS
Buffalo Scale Co., Inc.
Howe Scale Co., Inc.
Industrial Physics & Electronics Co.
Thurman Scale Co., Div. Thurman Mfg. Co.
Winslow Government Standard Scale Works, Inc.

SCALE-WEIGHT RECORDERS, CONVEYOR
Merrick Scale Mfg. Co.—"WEIGHTOMETER"

SCALES, AXLE-LOAD
Winslow Government Standard Scale Works, Inc.

SCALES, MINE-CAR TRUCK
Buffalo Scale Co., Inc.
Howe Scale Co., Inc.
Morse Bros. Machinery Co.
Thurman Scale Co., Div. Thurman Mfg. Co.
Winslow Government Standard Scale Works, Inc.

SCALES, PORTABLE TRUCK
Thurman Scale Co., Div. Thurman Mfg. Co.

SCALES, R. R.
Buffalo Scale Co., Inc.
Morse Bros. Machinery Co.
Howe Scale Co., Inc.
Winslow Government Standard Scale Works, Inc.

SCALES, TRUCK
Thurman Scale Co., Div. Thurman Mfg. Co.

SCALES, WEIGHING
Manning, Maxwell & Moore

Inc.
Shaw-Box Crane & Hoist Div.

SCRAPER TIPS, TEETH

American Brake Shoe Co., Amsco Div.—"AMSCO"

SCRAPERS, DRAG

Jeffrey Mfg. Co.
Joy Mfg. Co.
Laubenstein Mfg. Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Sauerman Bros., Inc.—"CRESCENT"

SCRAPERS, SELF-POWERED

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co. Industrial Equipment Div.
Caterpillar Tractor Co.
General Motors Corp., Euclid Division
International Harvester Co. Construction Equipment Div. —"PAYSCRAPER"
Joy Mfg. Co.
LeTourneau-Westinghouse Co. —"TOURNAPULL"

SCRAPERS, SELF-PROPELLED

Continental Copper & Steel Industries Inc., Wooldridge Div. —"CONTINENTAL WOOLDRIGE"

SCRAPERS, SHOT-HOLE

The Leetonia Tool Co.

SCRAPERS, TRACTOR-DRAWN

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Caterpillar Tractor Co.
Clark Equipment Co., Construction Machinery Div.—"MICHIGAN"
Continental Copper & Steel Industries, Inc., Wooldridge Div.—"Continental WOOLDRIDGE"
International Harvester Co., Construction Equipment Div.
LeTourneau-Westinghouse Co.
The Oliver Corp.

SCRAPERS, UNDERGROUND

Eimco Corp.
Joy Mfg. Co.

SCREEN BARS

Colorado Fuel & Iron Corp.—"C F & I"
Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Salem-Brosius, Inc.
Stephens-Adamson Mfg. Co.
W. S. Tyler Co.
Wedge Wire Corp.—"KLEEN-SLOT"

SCREEN CLOTH, WIRE

Bonded Scale & Machine Co.
Cambridge Wire Coth
Cleveland Wire Cloth & Mfg. Co.
Colorado Fuel & Iron Corp.—"C F & I"
Diamond Iron Works, Div. Goodman Mfg. Co.
John Flocker & Co.
Hewitt-Robins Incorporated—"GYRALOY," "SUPER GYRALOY"
Hoyt Wire Cloth Co.—"SUPERTOUGH," "ABRASO," "STAINLESS STEEL," "SMOOTHTOP," "LONGSLOT," "OBLONG," "DOUBLE CRIMP"
Iowa Mfg. Co.
Ludlow Saylor Wire Cloth Co. —"ARCHCRIMP," "STA-SMOOTH," "STA-CLEAN," "STA-TRU," "REKTANG," "LUDLOW," "SUPER-LOY," "PERFECT"

Newark Wire Cloth Co.
Simplicity Engineering Co.
W. S. Tyler Co.—"DOUBLE-CRIMP," "TON-CAP," "TY-ROD," "CORDUROY"

SCREEN-CLOTH HEATERS

The Deister Concentrator Co.—"FLEXELEX"
F. R. Hannon & Sons—"HANCO"
Link-Belt Co., Dept. CAMGL-58
Productive Equipment Corp.
Screen Equipment Co., Inc.—"HANNON"
Simplicity Engineering Co.
W. S. Tyler Co.—"TY-ELECTRIC"

SCREEN PLATE, PERFORATED

Bonded Scale & Machine Co.
Chicago Perforating Co.
John Flocker & Co.
The Harrington & King Perforating Co., Inc.
Hendrick Mfg. Co.
Robert Holmes & Bros., Inc.
Iowa Mfg. Co.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Laubenstein Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Remaly Mfg. Co. Inc.
Salem-Brosius, Inc.
W. J. Savage Co.
Simplicity Engineering Co.
Stephens-Adamson Mfg. Co.

SCREEN SECTIONS, REPLACEMENT

Cleveland Wire Cloth & Mfg. Co
Hoyt Wire Cloth Co.
Link-Belt Co., Dept. CAMGL-58

SCREENS

Hewitt-Robins Incorporated

SCREENS, CENTRIFUGAL

Bird Machine Co.—"BIRD-HUMBOLDT"
Cambridge Wire Cloth
Centrifugal & Mech. Industries, Inc.—"C-M-I"
Hendrick Mfg. Co.
Heyl & Patterson, Inc.—"RE-INEVELD"
Laubenstein Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Newark Wire Cloth Co.
Nordberg Mfg. Co.—"SY-MONS"
W. S. Tyler Co.

SCREENS, DEWATERING

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Bird Machine Co.
Bonded Scale & Machine Co.—"BONDED"
Cambridge Wire Cloth
Denver Equipment Co.—"DENVER"
Fairmont Machinery Co.
Hendrick Mfg. Co.
Hewitt-Robins Incorporated—"ELIPTEX DENWATERIZER"
Hoyt Wire Cloth Co.
Jeffrey Mfg. Co.
Laubenstein Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburgh Mfg. Corp.
Meckum Engr. Co.—"MECKUM SKB"
Newark Wire Cloth Co.
The Nolan Co.
Nordberg Mfg. Co. — "SY-MONS"
Productive Equipment Corp.—"GYROSET," "SELECTRO," "KELLEY"
Screen Equipment Co. Inc.—"SECO"
Simplicity Engineering Co.
Smith Engineering Works—"TELSMITH"
W. S. Tyler Co.
Wedge Wire Corp.—"KLEEN-SLOT"

SCREENS, DRIER

Laubenstein Mfg. Co.

SCREENS, INCLINED STATIONARY

Heyl & Patterson, Inc.—"H & P SIEVE BEND"

SCREENS, REVOLVING

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Denver Equipment Co.—"DENVER"
Diamond Iron Works, Div. Goodman Mfg. Co.
Gruendler Crusher & Pulverizer Co.
Hendrick Mfg. Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Laubenstein Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Lippmann Engrg. Works Inc.
McLanahan & Stone Corp.
Meckum Engr. Co.
Nordberg Mfg. Co.—"SY-MONS V-SCREEN"
Pioneer Engineering, Div. of Poor & Co.
W. J. Savage Co.
Smith Engineering Works—"TELSMITH"
W. S. Tyler Co.
Universal Engineering Corp.
Universal Road Machinery Co.—"RELIANCE"
Webster Mfg., Inc.

SCREENS, ROD

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Bixby-Zimmer Engineering Co.
Link-Belt Co., Dept. CAMGL-58
Nordberg Mfg. Co. — "SY-MONS"
W. S. Tyler Co.—"TY-LOC"

SCREENS, SHAKER

Bonded Scale & Machine Co.—"BONDED"
Cambridge Wire Coth
Central Scientific Co.
Colorado Fuel & Iron Corp.
Fairmont Machinery Co.
Fisher Scientific Co.
Gruendler Crusher & Pulverizer Co.
Helmick Foundry-Machine Co.
Hendrick Mfg. Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Hoyt Wire Coth Co.
Industrial Engrg. & Construction Co., Inc.
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Laubenstein Mfg. Co.
Link-Belt Co., Dept, CAMGL-58
McLanahan & Stone Corp.
McNally-Pittsburg Mfg. Corp.
Newark Wire Cloth Co.
K. Prins & Associates
Remaly Mfg. Co. Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.
Stephens-Adamson Mfg. Co.
W. S. Tyler Co.

SCREENS, TESTING

Commercial Testing & Engineering Co.

SCREENS, VIBRATING

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Bonded Scale & Machine Co.—"BONDED"
Cambridge Wire Cloth
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
The Deister Concentrator Co.—'LEAHY HEAVY DUTY NO BLIND"
Diester Machine Co.
Denver Equipment Co.—"DEN-VER-DILLON"
Diamond Iron Works, Div. Goodman Mfg. Co.
Dravo Corp.
Fairmont Machinery Co.
Gruendler Crusher & Pulverizer Co.
Hendrick Mfg. Co.
Hewitt-Robins Incorporated—"HI-G," "VIBREX," "ELIPTEX," "GYREX," 'HI-SPEED," "HYDREX"
Hoyt Wire Cloth Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Kennedy-Van Saun Mfg. & Engrg. Corp.
Lecco Machinery & Engineering Co.—'LECCO-VIB"
Link-Belt Co., Dept. CAMGL-58—"BA," "CA"
Lippmann Engrg. Works Inc.
McLanahan & Stone Corp.
McNally-Pittsburg Mfg. Corp.
Morse Bros. Machinery Co.
Newark Wire Cloth Co.
Nordberg Mfg. Co.—'SY-MONS"
Ore Reclamation Co.
Pioneer Engineering, Div. of Poor & Co.—'SUPER SERVICE MESABI"
Productive Equipment Corp.—"GYROSET," "SELECTRO," "KELLEY"
Remaly Mfg. Co. Inc.
Screen Equipment Co. Inc.—"SECO"
Simplicity Engineering Co.—"SIMPLI-FLO"
Smith Engineering Works—"TELSMITH"
Stedman Foundry & Machine Co., Inc.
Stephens-Adamson Mfg. Co.
Straub Mfg. Co., Inc.
Sturtevant Mill Co.
Syntron Co.
W. S. Tyler Co.—"HUMMER," "TY-ROCK," "TY-LER-NIAGARA," "TY-ROCKET"
Universal Engineering Corp.
Universal Vibrating Screen Co.—"UNIVERSAL," 'UNI-LEC," "UNIFLEX"
Williams Patent Crusher & Pulv. Co.

SCREENS, VIBRATING, TESTING

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Denver Equipment Co.—"DEN-VER-DILLON"
Hendrick Mfg. Co.
Robert Holmes & Bros., Inc.
Link-Belt Co., Dept. CAMGL-58
Newark Wire Cloth Co.
Productive Equipment Corp.
Syntron Co.
W. S. Tyler Co.—"RO-TAP," "TY-LAB"
Universal Vibrating Screen Co.—"UNIVIBE"

SCREENS, WEDGE-WIRE

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Bixby-Zimmer Engineering Co.
Hendrick Mfg. Co.—"WEDGE-SLOT"
Wedge Wire Corp—"KLEEN-SLOT"

SCREW WASHERS

Link-Belt Co., Dept. CAMGL-58

SCREWS, SET

The Leetonia Tool Co.

SCRUBBERS, AIR

Johnson-March Corp.—"TYPE A HYDRO-PRECIPITATOR"

SEALS, BEARING, GREASE & OIL

Bearings, Inc.
The Garlock Packing Co.—"KLOZURES"
Johns-Manville—"CLIPPER"
United States Rubber Co.
West Virginia Armature Co.

SEALS, SHAFT, MECHANICAL

Anchor Packing Co.
Bearings, Inc.
Byron Jackson Pumps, Inc. A Sub. of Borg-Warrer Corp.
The Garlock Packing Co.—"MECHANIPAK"
Koppers Co., Inc., Metal Products Div.
Syntron Co.
United States Rubber Co.

SECTIONALIZING APPARATUS, STRIPPING

Atkinson Armature Works

SEISMOGRAPHS, BLASTING

Vibration Measurement Engineers, Inc.—"SEISMOLOG"

SELF-RESCUERS

Mine Safety Appliances Co.

SEPARATORS, AIR

Hardinge Co., Inc.
I-T-E Circuit Breaker Co.
Majac Inc., Sub. of Blackstone Corp.
New Jersey Meter Co.—"DRIAIR"
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Sturtevant Mill Co.
Universal Road Machinery Co.—"GAYCO"
Williams Patent Crusher & Pulv. Co.

SEPARATORS, HEAVY-MEDIA

Link-Belt Co., Dept. CAMGL-58
Western Machinery Co.—"WEMCO CONE," "WEMCO DRUM"

SEPARATORS, METAL, MAGNETIC AND MAGNETIC CONVEYOR

Infilco Inc—"MAGNEFLEX," "FLEXI-FLIGHT"

SEPARATORS, VIBRATING SCREEN

Southwestern Engineering Co.

SERVICE TRUCKS, SELF PROPELLED

Schroeder Brothers Corp.

SHAFT HANGERS

J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
W. J. Savage Co.
Webster Mfg., Inc.
Wilmot Engineering Co.

SHAFT MOTION INDICATOR

Bin-Dicator Co.—"ROTO-GUARD"

SHAFT RIGS, PNEUMATIC

Schroeder Brothers Corp.

SHAFT & TUNNEL, SUPPORTS STEEL, PLATES, RIBS, SETS & LAGGING

Commercial Shearing & Stamping Co.

SHAFTING, STEEL

Bethlehem Steel Co.
Bonded Scale & Machine Co.
Robert Holmes & Bros., Inc.
Jeffrey Mfg. Co.
Jones & Laughlin Steel Corp.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Joseph T. Ryerson & Son, Inc.
W. J. Savage Co.
Transall, Inc.
Bertrand P. Tracy Co.

SHAPERS
South Bend Lathe Works

SHAPES, STRUCTURAL, ALUMINUM
Aluminum Company of America
Robert Holmes & Bros., Inc.
Reynolds Metals Co.

SHEARS, PORTABLE ELECTRIC
Black & Decker Mfg. Co.

SHEAVES, BICYCLE-TYPE
Connellsville Mfg. & Mine Supply Co.

SHEAVES, FABRICATED
Connellsville Mfg. & Mine Supply Co.

SHEAVES, HOISTING
American Brake Shoe Co., Amsco Div.—"AMSCO"
C. S. Card Iron Works
Robert Holmes & Bros., Inc.
Kensington Steel, Div. of Poor & Co.
Nordberg Mfg. Co.
Pittsburgh Gear Co.
Sanford Day Iron Works, Inc.
Sauerman Bros., Inc.—"DUROLITE"
The Tool Steel Gear & Pinion Co.
Vulcan Iron Works—"ALL-CASTEEL"
Wilmot Engineering Co.

SHEAVES, TRACK
C. S. Card Iron Works
Robert Holmes & Bros., Inc.
Pittsburgh Gear Co.
Sanford Day Iron Works, Inc.
Sauerman Bros., Inc.—"DUROLITE"

SHEAVES, V-BELT
Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"TEXROPE"
The American Pulley Co.—"WEDG-TITE"
Bonded Scale & Machine Co.
Boston Woven Hose & Rubber Co., Div. of American Biltrite Co.
Browning Mfg. Co.
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
The Dayton Rubber Co.
Dodge Mfg. Corp.—"TAPER LOCK"
Flood City Brass & Electric Co.
The Gates Rubber Co. Sales Div., Inc.
Guyan Machy. Co.
Hewitt-Robins Incorporated—"JONES"
Industrial Rubber Products Co. (Pa.)
Iowa Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McLanahan & Stone Corp.
McNally-Pittsburgh Mfg. Corp.
Meckum Engr. Co.
National Mine Service Co.
Ore Reclamation Co.
Pittsburgh Gear Co.
Transall, Inc.
T. B. Woods Sons Co.
Worthington Corp.

SHEAVES, WIRE-ROPE
American Brake Shoe Co., Amsco Div.—"AMSCO"
C. S. Card Iron Works
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
Robert Holmes & Bros., Inc.
Joy Mfg. Co.
Kensington Steel, Div. of Poor & Co.
Nordberg Mfg. Co.
Pittsburgh Gear Co.
Sanford Day Iron Works, Inc.
Sauerman Bros., Inc.—"DUROLITE"
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
Vulcan Iron Works—"ALL-CASTEEL"
T. B. Woods Sons Co.

SHELVING, RACKS, ETC.
The Frick-Gallagher Mfg. Co.—"CLIP-BILT"
National Mine Service Co.
Miners' Hardware Supply Co.—"LYONS"

SHIM STOCK, SHIMS
Crucible Steel Co. of America
B. F. Goodrich Industrial Products Co.

SHOCK ABSORBERS, MACHINE & MOTOR MOUNTS
Continental Rubber Works
Goodyear Tire & Rubber Co.
United States Rubber Co.

SHOTFIRERS
American Mine Door Co.
Femco, Inc.
King Powder Co., Inc.
Mine Safety Appliances Co.
National Mine Service Co.
Olin-Mathieson Chemical Corp., Explosives Div.

SHOVELS, HAND
National Mine Service Co.
The Salem Tool Co.—"RED DEVIL"
The Wood Shovel & Tool Co.

SHOVELS, STANDARD POWER-TYPE, COAL LOADING
American Hoist & Derrick Co.—"AMERICAN"
Baldwin-Lima-Hamilton Corp., Construction Equipment Div.—"LIMA"
Bucyrus-Erie Co.
Gar Wood Industries, Inc.
Harnischfeger Corp.
Koehring Div. of Koehring Co.
Link-Belt Speeder Corp.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
Orton Crane & Shovel Co.
"Quick-Way" Truck Shovel Co.
Schield Bantam Co.
The Thew Shovel Co.—"LORAIN"
Unit Crane & Shovel Corp.

SHOVELS, STRIPPING
American Hoist & Derrick Co.—"AMERICAN"
Baldwin-Lima-Hamilton Corp., Construction Equipment Div.—"LIMA"
Bucyrus Erie Co.
Harnischfeger Corp.
Koehring Div. of Koehring Co.
Link-Belt Speeder Corp.
Manitowoc Engineering Corp.
Marion Power Shovel Co., a Div. of Universal Marion Corp.
Northwest Engineering Co.
"Quick-Way" Truck Shovel Co.
The Thew Shovel Co.—"LORAIN"

SHOVELS, TRACTOR
Allis-Chalmers Mfg. Co., Construction Machinery Div.

SHOVELS, TRACTOR MOUNTED
Eimco Corp.

SHOWER-ROOM EQUIPMENT
Onox, Inc.—"ONOX FOOT-MATS, ONOX SKIN-TOUGHENER"

J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

SHUTTLE TRAINS, GANGWAY DEVELOPMENT, ELECTRIC, AIR

Herold Mfg. Co.

SIEVES, TESTING

Central Scientific Co.
Fisher Scientific Co.
Newark Wire Cloth Co.
W. S. Tyler Co.—"TYLER STANDARD-SCREEN SCALE"

SIGNALS, HAULAGE

American Mine Door Co.

SIGNALS, HIGHWAY CROSSING

Union Switch Signal Div. Westinghouse Air Brake Co.

SIGNALS, LIGHT CASES

American Mine Door Co.
Nachod & U. S. Signal Co.

SILOS, ASH, COAL & SAND STORAGE

Link-Belt Co., DEPT. CAMGL-58
Marietta Concrete Corp.
Neff & Fry Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

SKIDS, MINE-CAR

Duquesne Mine Supply Co.
Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.
Miners' Hardware Supply Co.
Sanford Day Iron Works, Inc.

SKIN CREAMS, PROTECTIVE

American Optical Co., Safety Products Div.—"SAFETI-COTE"

SKIP WHEELS

American Brake Shoe Co., Amsco Div.—"AMSCO"

SKIPS, AUTOMATIC LOADING EQUIPMENT

Robert Holmes & Bros., Inc.

SKIPS, MINE-HOISTING

Connellsville Mfg. & Mine Supply Co.
Hewitt-Robins Incorporated
Robert Holmes & Bros., Inc.
Mayo Tunnel & Mine Equipment Co.
The Stearns-Roger Mfg. Co.
Vulcan Iron Works
Webster Mfg., Inc.

SLINGS, BELT

C. R. Daniels Co.
B. F. Goodrich Co., Industrial Products Div.
Goodyear Tire & Rubber Co.
Hewitt-Robins Incorporated
Raybestos Manhattan, Inc., Manhattan Rubber Div.

SLINGS, CHAIN

American Chain & Cable Co., Inc., American Chain Div.
John Flocker & Co.
Manning, Maxwell & Moore, Inc. Shaw-Box Crane & Hoist Div.—"TIPIT"
Joseph T. Ryerson & Son, Inc.

SLINGS, WOVEN WIRE

Cambridge Wire Cloth

SLINGS, WIRE-ROPE

American Chain & Cable—"ACCO REGISTERED," "DUALOC"
Bergen Wire Rope Co.
Bethlehem Steel Co.
Broderick & Bascom Rope Co.—"YELLOW STRAND" "B & B BROLOC," "THRIF-T-LIFT"
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.—"WICKWIRE" "MAXI-FLEX," "MULTIFLEX" "DURAGRIP"
Electric Steel Foundry Co.
John Flocker & Co.
Jones & Laughlin Steel Corp.
Leschen Wire Rope Div., H. K. Porter Co., Inc.
Macwhyte Wire Rope Co.
National Mine Service Co.
John A. Roebling's Sons Corp., Sub. Colorado Fuel & Iron Corp.
Joseph T. Ryerson & Son, Inc.
Union Wire Rope Corp. Sub. of Armco Steel Corp.—"TUFFY"
Upson-Walton Co. — "MAX-Wire Rope Corp. of America, Inc.—"WIRECO"

SLOTTERS

Farrel-Birmingham Co., Inc.

SLUDGE RECOVERY SYSTEMS

Link-Belt Co., Dept. CAMGL-58

SLUSHERS, SCRAPER

Joy Mfg. Co.

SOILS, TESTING

Mobile Drilling Inc.

SOLENOIDS

Cheatham Elec. Switching Device Co.
Cutler-Hammer, Inc.
General Electric Co., Apparatus Sales Div.

SOLVENTS, CLEANING

American Minechem Co.
Cities Service Oil Co.
Columbia-Southern Chemical Corp.
E. I. du Pont de Nemours & Co., Inc.
Esso Standard Oil Co.—"VARSOL," "ESSO VARSOL"
Fisher Scientific Co.
Martindale Electric Co.
Shell Oil Co.
Socony Mobile Oil Co. Inc.
Sun Oil Co.
Wyandotte Chemicals Corp.

SOUND PROTECTORS

American Optical Co., Safety Products Div.—"STRAIGHT-AWAY"

SPAD DRIVERS

American Mine Supply Co.

SPAD HANGERS

American Mine Supply Co.

SPADS

American Mine Supply Co.
Black Diamond Spad Co.—"BLACK DIAMOND"
Howells Mining Drill Co.—"HOWELLS"

SPECTACLES, SAFETY

American Optical Co., Safety Products Div.—"FULVUE ULTRASCOPIC"
E. D. Bullard Co.
Fisher Scientific Co.
General Scientific Equipment Co.—"GS"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.
United States Safey Service Co.—"STYL-IZE"

SPEED INCREASERS

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"VARIPITCH"
J. D. Christian Engineers
Falk Corp.—"FALK"
Farrel-Brimingham Co., Inc.
Hewitt-Robins Incorporated—"JONES"
Link-Belt Co., Dept. CAMGL-58
U. S. Electrical Motors, Inc.—"SYNCRO GEAR"
Westinghouse Electric Corp.
Worthington Corp.

SPEED REDUCERS

Allis-Chalmers Mfg. Co., Industrial Equipment Div.—"VARIPITCH"
The American Pulley Co.—"SHAFT-KING," "SCREW-KING"
Bonded Scale & Machine Co. "RITE LO SPEED"
J. D. Christian Engineers —
Cleveland Worm & Gear Co.—"CLEVELAND," "SPEED-AIRE"
Coal Machinery Research, Inc.
Cone-Drive Gears Div., Michigan Tool Co.
Continental Gin Co., Ind. Div.
Dodge Mfg. Corp.—"TORQUE-ARM."
Falk Corp.—FALK"
Farrel-Brimingham Co., Inc.
Foote Brothers Gear & Machinery Corp.—"HYGRADE," "LINE-O-POWER," "MAXI-POWER," "LINE-O-MOUNT"
Hewitt-Robins Incorporated—"JONES"
Link-Belt Co. Dept. CAMGL-58—"LINK-BELT," "IN-LINE HELICAL," "PARALLEL SHAFT," "GEAR-MOTOR," 'P. I. V.," "WORM," MOTOGEAR"
The Master Electric Co.
Mining Progress, Inc.
Morse Chain Co., A Borg-Warner Industry—"EBERHARDT DENVER"
Ore Reclamation Co.
Stephens-Adamson Mfg. Co.—"SACO"
Sterling Electric Motors, Inc.—"STERING MUTLI-MOUNT"
Transall, Inc.
U. S. Electrical Motors, Inc.—"SYNCROGEAR"
Vickers, Inc., Tulsa Winch Div.—"TULSA"
Westinghouse Electric Corp.
Worthington Corp.

SPEED REDUCERS, WORM

Link-Belt Co., Dept. CAMGL-58

SPIKES, TRACK—See Rail Spikes

SPIRALS, COAL

Mining Progress, Inc.
Western Machinery Co.—"WEMCO"
Splicing compounds, Materials—See Conveyor Belting Splicing Materials

SPRAY COMPOUNDS

Fuel Process Co.
Johnson-March Corp.—"COMPOUND MR"

SPRAY OILS

Ashland Oil & Refining Co.—"ASHLAND PERMA-TREAT"
Cities Service Oil Co.
Esso Standard Oil Co.
Keenan Oil Co.—"KEENOIL 7"
Shell Oil Co.
Socony Mobil Oil Co. Inc.
The Southland Co.
Standard Oil Co. (Ind.)
Sun Oil Co.—'COAL KOTE"
The Texas Co.
Valvoline Oil Co., Div Ashland Oil & Refining Co.

SPRAYERS, HIGH-PRESSURE

Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.

SPRAYING EQUIPMENT—See also Dustproofing Equipment

SPRAYING EQUIPMENT, OIL

Gray & Co., Inc.
Keenan Oil Co.
Sanford Day Iron Works, Inc.
W. J. Savage Co.

SPRAYING EQUIPMENT, WATER & COMPOUNDS

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AEROSPRAY 52 BINDER"
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp.
Johnson-March Corp.

SPROCKETS

Acme Chain Co.
American Brake Shoe Co., Amsco Div.—"AMSCO"
Bonded Scale & Machine Co.
Browning Mfg. Co.
Chain Belt Co.—"REX"
J. D. Christian Engineers
Continental Gin Co., Ind. Div.
Diamond Chain Co., Inc.
Dodge Mfg. Corp.—"TAPER LOCK"
Guyan Machy. Co.
Helmick Foundry-Machine Co.
Iowa Mfg. Co.
Jeffrey Mfg. Co.
Kensington Steel, Div. of Poor & Co.
Link-Belt Co., Dept. CAMGL-58—"LINK-BELT," 'FLINT RIM," "DOUBLE DUTY," "TAPER LOCK"
McLanahan & Stone Corp.
McNally-Pittsburgh Mfg. Corp.
Meckum Engr. Co.
Mining Machine Parts, Inc. "MANGALOY"
Mosebach Electric & Supply Co.
National Mine Service Co.
Ore Reclamation Co.
Penn Machine Co.
W. J. Savage Co.
Taylor-Wharton Co. Div. Harsco Corp.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.
Transall, Inc.
Whitney Chain Co.
Wilmot Engineering Co.

SPROCKETS, CAST-IRON

Link-Belt Co., Dept. CAMGL-58
Webster Mfg., Inc.

SPROCKETS, COAL CUTTERS

Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Frank Prox Company, Inc.
The Tool Steel Gear & Pinion Co.
Bertrand P. Tracy Co.

SPROCKETS, CUT-TOOTH

Link-Belt Co., Dept. CAMGL-58

SPROCKETS, ROLLER CHAIN

Flood City Brass & Electric Co.
Link-Belt Co., Dept. CAMGL-58

SPROCKETS, SILENT CHAIN

Link-Belt Co., Dept. CAMGL-58
Morse Chain Co., A Borg-Warner Industry

SPROCKETS, TAPER-BORE

Link-Belt Co., Dept. CAMGL-58

SPROCKETS, TIMING-BELT

Morse Chain Co., A Borg-Warner Industry

STACKERS, RECLAIMERS, COAL

Barber-Greene Co.
Dravo Corp.
Hewitt-Robins Incorporated
Link-Belt Co., Dept. CAMGL-58
Pioneer Engineering, Div. of Poor & Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

STAIR TREADS
Blaw-Knox Co.
Dravo Corp.
General Scientific Equipment Co.—"GS"
Jones & Laughlin Steel Corp. —"JAL-TREAD," "JUNIOR "JAL-TREAD"
Joseph T. Ryerson & Son, Inc.

STARTERS—See Motor Controllers, Starters

STEAM GENERATORS
Clayton Mfg. Co. — "CLAYTON"

STEAM TRACED PIPE, ALUMINUM
Aluminum Co. of America—"UNITRACE"

STEEL, ABRASION-RESISTING
American Brake Shoe Co., Amsco Div—"AMSCO"
American Steel & Wire Div., U.S. Steel Corp.
Bethlehem Steel Co.
A. M. Byers Co.—"BYLOY W-2"
Crucible Steel Co. of America
Electric Steel Foundry Co.
Jones & Laughlin Steel Corp.—"JALLOY"
Kanawha Mfg. Co.
Republic Steel—'REPUBLIC"
Stulz-Sickles Co.—"MAN-GANAL"
Taylor-Wharton Co., Div., Harsco Corp.
United States Steel Corp. — "USS A-R"
Youngstown Sheet & Tube Co.

STEEL, ALLOY
American Brake Shoe Co., Amsco Div.—"AMSCO"
American Steel & Wire Div., U. S. Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
Crucible Steel Co. of America
Electric Steel Foundry Co.
Jones & Laughlin Steel Corp.—"JALLOY"
Kanawha Mfg. Co.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Sheffield Div., Armco Steel Corp.
Stulz-Sickles Co.
The Timken Roller Bearing Co.
United States Steel Corp.—"USS CARILLOY," "USS T-1," "USS FC," "USS SU-PERKORE"
Youngstown Sheet & Tube Co.

STEEL, ALLOY, FREE MACHINING
Crucible Steel Co. of America

STEEL, CARBON
American Steel & Wire Div., U. S. Steel Corp.
Bethlehem Steel Co.
Crucible Steel Co. of America
Colorado Fuel & Iron Corp.—"C F & I"
Inland Steel Co.
Jones & Laughlin Steel Corp.
Kanawha Mfg. Co.
Phoenix Iron & Steel Co., Structural & Tube Divs.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Sheffield Div., Armco Steel Corp.
United States Steel Corp.
Youngstown Sheet & Tube Co.

STEEL, CORROSION-RESISTANT
Allegheny Ludlum Steel Corp.
Bethlehem Steel Co.
Crucible Steel Co. of America
Electro-Alloys Div. American Brake Shoe Co.
Jones & Laughlin Steel Corp.
Kanawha Mfg. Co.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Youngstown Sheet & Tube Co.

STEEL, GALVANIZED
Inland Steel Co.—"TM-TI-Co"

STEEL, HEAT RESISTANT ALLOY
Electro-Alloys Div., American Brake Shoe Co.

STEEL, HIGH-STRENGTH
American Steel & Wire Div., U. S. Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
Crucible Steel Co. of America
Inland Steel Co.—"TM-HI-STEEL," "HI-MAN"
Jones & Laughlin Steel Corp. —"JALTEN"
Kanawha Mfg. Co.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
Sheffield Div., Armco Steel Corp.
Stulz-Sickles Co.
United States Steel Corp.—"USS CORTEN," "USS MAN-TEN," "USS TRI-TEN"
Youngstown Sheet & Tube Co.

STEEL, REINFORCING
Bethlehem Steel Co.

STEEL, SPECIAL SECTIONS
H. K. Porter Co., Connors Steel Div.

STEEL, STAINLESS
Allegheny Ludlum Steel Corp.
American Steel & Wire Div., U. S. Steel Corp.
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.
Crucible Steel Co. of America
Disston Div., H. K. Porter Co., Inc.
Electric Steel Foundry Co.
Kanawha Mfg. Co.
Republic Steel—"REPUBLIC ENDURO"
Joseph T. Ryerson & Son, Inc.
W. J. Savage Co.
United States Steel Corp.

STEEL, STRUCTURAL
Arrowhead Constructors and Engineers, Inc.
Colorado Fuel Iron Corp.—"C F & I"
Bethlehem Steel Co.
Dravo Corp.
M. Glosser & Sons Inc.
Robert Holmes & Bros., Inc.
Inland Steel Co.
Jones & Laughlin Steel Corp.—"JUNIOR BEAMS," "JUNIOR TEES," "JUNIOR CHANNELS"
Kanawha Mfg. Co.
Phoenix Iron & Steel Co., Structural & Tube Divs.
H. K. Porter Co., Connors Steel Div.
Joseph T. Ryerson & Son, Inc
W. J. Savage Co.
Sheffield Div., Armco Steel Corp.
United States Steel Corp.

STEEL, TOOL
Allegheny Ludlum Steel Corp.
Bethlehem Steel Co.
Crucible Steel Co. of America—"REX"
Gardner-Denver Company
Jones & Laughlin Steel Corp.
Republic Steel—"REPUBLIC"
Joseph T. Ryerson & Son, Inc.
The Timken Roller Bearing Co.

STOKERS
Axeman-Anderson Co.—"ANTHRATUBE"

STOKERS, CHAIN-GRATE
Laclede Stoker Co.—"LA-CLEDE 'F' TYPE," "LA-CLEDE 'L' TYPE"
Combustion Engineering, Inc.—"C-E"

STOKERS, SPREADER
American Engineering Co. — "AE PERFECT SPREAD"
Combustion Engineering, Inc.—"C-E"
Dayton Automatic Stoker Co.
Hoffman Combustion Engrg. Co.—"FIRITE"
Laclede Stoker Co.—"LAC-LEDE-UNIVERSAL"

STOKERS, TRAVELING GRATE
Combustion Engineering, Inc.—"C-E"

STOKERS, UNDERFEED
American Engineering Co.—"TAYLOR"
Auburn Foundry, Inc., Heating Div.—"AUBURN"
Canton Stoker Corp.—"CAN-TON"
Carpenter Heating & Air Conditioning Co.—"CARPEN-TER"
Combustion Engineering, Inc.—"C-E"
Dayton Automatic Stoker Co.—"MARINE"

STOKERS, VIBRATING GRATE
American Engineering Co.—"VIBRA-GRATE"

STOPERS, ROOF-BOLTING
Acme Machinery Co.
Gardner-Denver Company
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.—"VAC-NU-MATIC"
Penn Machine Co.
Schroeder Brothers Corp.
Thor Power Tool Co.

STOPPING, SOLID-PLASTIC
Mine Ventilation Systems, Inc.

STOPPINGS, STEEL DEMOUNTABLE
Tri-County Building Service—"AIRTITE"

STORAGE PILE PROTECTIVE COATING
Johnson-March Corp.—"COM-POUND SP"

STORAGE SYSTEMS, COAL
Link-Belt Co., Dept. CAMGL-58

STOVES, HEATING
Cowanesque Valley Iron Works

STOVES, SAND DRYING
Cowanesque Valley Iron Works

STOWING MACHINES, BELT SLINGERS
Herold Mfg. Co.

STOWING MACHINES, PNEUMATIC
Herold Mfg. Co.

STRAIN GAGE LOAD CELLS
Cox & Stevens Electronic Scales Div., Revere Corp. of America

STRAINERS, PUMP
Barrett, Haentjens & Co.
Goyne Pump Co.
S. P. Kinney Engineers, Inc.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

STRAINERS, WIRE CLOTH
Cleveland Wire Cloth Co.

SUBSTATIONS, OUTDOOR
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Delta-Star Electric Div., H. K. Porter Co., (Delaware)
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.
Westinghouse Electric Corp.

SUBSTATIONS, UNIT
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.
Westinghouse Electric Corp.

SUGGESTION SYSTEMS, POSTERS, BOXES, FORMS
Elliott Service Co., Inc.

SUPERVISORY-CONTROL SYSTEMS
B-I-F Industries, Inc.—"SYN-CHRO-SCAN"
The Bristol Co.—"META-METER TELEMETERING"
Femco, Inc.
Industrial Physics & Electronics Co.
General Electric Co., Apparatus Sales Div.

SURVEYING EQUIPMENT
C. L. Berger & Sons, Inc.—"BERGER"
Charles Bruning Co., Inc.
Copperweld Steel Co., Wire & Cable Div.
Geo-Optic Co., Inc.
Gurley, W. & L. E.
Wild Heerbrugg Instruments, Inc.

SUSPENSION, FEEDER
The Elreco Corp.

SWEATBANDS
American-Optical Co. Safety Products Div.
Pulmosan Safety Equip .Co

SWITCHBOARDS
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Cutler Hammer Inc.
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.—
Ironton Engine Co.,—"IRON-TON"
Joy Mfg. Co.
Mosebach Electric & Supply Co.
Westinghouse Electric Corp.

SWITCH BOXES
General Electric Co., Construction Materials Div.
Joy Mfg. Co.
Mosebach Electric & Supply Co.
National Electric Products Co.
Westinghouse Electric Corp.

SWITCH HOUSES
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Mosebach Electric & Supply Co.
Westinghouse Electric Corp.

SWITCHERS, RR CAR
LeTourneau-Westinghouse Co—"SWITCH MOBILE" "SWITCH-TRACTOR"

SWITCHES, AIR FLOW CONTROLLED MERCURY TUBE
Guyan Machy. Co.

SWITCHES, BELT CONTROL
Schroeder Brothers Corp.

SWITCHES, CONTROL, MOTORMAN OPERATED
Cheatham Electric Switching Device Co.
Nachod & U. S. Signal Co.

SWITCHES, CONVEYOR-CONTROL
General Electric Co., Apparatus Sales Div.
Joy Mfg. Co.
Westinghouse Electric Corp.

SWITCHES, ELECTRIC HAND
American Mine Door Co.

SWITCHES, ELECTRICAL
Arrow Hart & Hegeman Elec-

tric Co.—"QUIETTE"
Circuit Protective Devices Dept., General Electric Co.
Clark Controller Co.
Cutler-Hammer, Inc.
Dooley Brothers
The Elreco Corp.—"POWER"
G & W Electric Specialty Co.
General Electric Co., Apparatus Sales Div.
General Electric Co., Construction Materials Div.
I-T-E Circuit Breaker Co.
Joy Mfg. Co.
Ohio Brass Co.
Mosebach Electric & Supply Co.
National Mine Service Co.
Stackpole Carbon Co.
Westinghouse Electric Corp.

SWITCHES, ELECTRICAL HIGH-VOLTAGE

Delta-Star Electric Div., H. K. Porter Co., (Delaware)

SWITCHES, ELECTRICAL, SAFETY

Arrow Hart & Hegeman Electric Co.
Circuit Protective Devices Dept., General Electric Co.
Crouse-Hinds Co.
Cutler-Hammer, Inc.—"C-H"
Dooley Brothers
General Electric Co., Apparatus Sales Div.
Joy Mfg. Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.
Westinghouse Electric Corp.

SWITCHES, LOCOMOTIVE TRANSFER

Circuit Protective Devices Dept., General Electric Co.
Flood City Brass & Electric Co.
General Electric Co., Apparatus Sales Div.
Jeffrey Mfg. Co.
The Post Glover Electric Co.—"P-G"

SWITCHES, MERCURY

Crouse-Hinds Co.
Durakool, Inc.
General Electric Co., Construction Materials Div.
Joy Mfg. Co.
The Post Glover Electric Co.—"P-G"

SWITCHES, PRESSURE

Barksdale Valves

SWITCHES, ROPE-PULL MOMENTARY

American Mine Door Co.

SWITCHES, THERMOCOUPLE

West Instrument Corp.

SWITCHGEAR

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Electric Machinery Mfg. Co.
General Electric Co., Apparatus Sales Div.
I-T-E Circuit Breaker Co.
Herbert S. Littlewood
Westinghouse Electric Corp.

SWITCHGEAR, PORTABLE, SHOVEL CABLES

Atkinson Armature Co.

TABLE DECKS, WASHING

Linatex Corp. of America

TABLES, AIR-CLEANING

Fairmont Machinery Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.—"SUPER-AIRFLOW"

TABLES, COAL-WASHING

The Daniels Co., Contractors, Inc.
The Deister Concentrator Co.—"SUPER DUTY DIAGONAL DECK," "CONCENCO '77' DIAGONAL DECK"
Deister Machine Co.

Link-Belt Co., Dept. CAMGL-58

TABLES, DRAFTING

Charles Bruning Co. Inc.

TACHOMETERS

The Bristol Co.—"BRISTOL'S"
Fisher Scientific Co.
Foxboro Co.
General Electric Co., Apparatus Sales Div.
Ideal Industries, Inc.
Martindale Electric Co.
Minneapolis-Honeywell Regulator Co., Industrial Division
Stewart-Warner Corp., Alemite Div.
Westinghouse Electric Corp.

TAKEOFFS, POWER

Gar Wood Industries, Inc.
Schroeder Brothers Corp.
Twin Disc Clutch Co.
Vickers, Inc., Tulsa Winch Div.—"TULSA"

TAKEOFFS, POWER, SPLIT SHAFT TYPE

Hendrickson Mfg. Co.

TAKEUPS, BALL, ROLLER

Dodge Mfg. Corp.

TAKEUPS, CONVEYOR

Barber-Greene Co.
Bearings, Inc.
Chain Belt Co., Shafer Bearing Div.
J. D. Christian Engineers
Hewitt-Robins, Incorporated
Irwin Foundry & Mine Car Co.
Jeffrey Mfg. Co.
Joy Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp.
Pioneer Engineering, Div. of Poor & Co.
Roberts & Schaefer Co., Sub Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

TAKEUP UNITS, BALL-BEARING

Link-Belt Co., Dept. CAMGL-58

TAKEUP UNITS, SPHERICAL ROLLER BEARING

Link-Belt Co., Dept. CAMGL-58

TAMPERS, PNEUMATIC

Schroeder Brothers Corp.

TAMPERS, SHOTHOLE

The Leetonia Tool Co.

TAMPING BAGS—See Bags, Tamping

TAMPING PLUGS

Charles Abbott & Associates—"TRUBLAST RAPID"
National Mine Service Co.
National Powder Co.

TAMPING POLES, HEADS

The Salem Tool Co.

TAMPING STICKS, WOOD

Duquesne Mine Supply Co.
J. V. Hammond Co.
National Mine Service Co.
National Powder Co.
The Salem Tool Co.—"BLACK DIAMOND"

TANK-LEVEL CONTROLS

Industrial Nucleonics Corp.—"ACCURAY"

TANKS, CLARIFYING, SLUDGE RECOVERY

Fairmont Machinery Co.
Denver Equipment Co.—"DENVER"
Eagle Iron Works
Link-Belt Co., Dept. CAMGL-58
Peterson Filters & Engineering Co.

K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

TANKS, PLASTIC-LINED

Galigher Co.

TANKS, RUBBER-LINED

Denver Equipment Co.—"DENVER"
Galigher Co.
The Gates Rubber Co. Sales Div., Inc.
B. F. Goodrich Industrial Products Co.
Industrial Rubber Products Co. (Pa.)
Linatex Corp. of America
Quaker Rubber Div., H. K. Porter Co.
Raybestos Manhattan, Inc. Manhattan Rubber Div.
United States Rubber Co.

TANKS, STEEL

Bethlehem Steel Co.
The Daniels Co., Contractors, Inc.
Denver Equipment Co.—"DENVER"
Enterprise Wheel & Car Corp.
Robert Holmes & Bros., Inc.
Kanawha Mfg. Co.
L. O. Koven & Bro., Inc.
Phoenix Iron & Steel Co., Structural & Tube Division
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
W. J. Savage Co.

TANKS, WOOD

Denver Equipment Co.—"DENVER"
Fluor Products Co.
The Hauser-Stander Tank Co.

TAPE, ADHESIVE

Johns-Manville—"DUTCH BRAND"

TAPE, BONDING

B. F. Goodrich Industrial Products Co.

TAPE, COATED, POLYESTER MAT

Irvington Div. of Minnesota Mining & Mfg. Co.

TAPE, ELECTRICAL, PLASTIC

Boston Woven Hose & Rubber Co., Div. of American Biltrite Rubber Co.
Continental Rubber Works
The Dayton Rubber Co.—"HOL-FAST"
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Johns-Manville — "JOMANCO"
Minnesota Mining & Mfg. Co.—"SCOTCH NO. 33, 22, 21 & 20"
National Mine Service Co.
Okonite Co.
Plymouth Rubber Co.—"SLIPKNOT"
United States Rubber Co.

TAPE, ELECTRICAL, GLASS-CLOTH

Minnesota Mining & Mfg. Co.—"SCOTCH NO. 27"

TAPE, ELECTRICAL, THERMOSETTING

Minnesota Mining & Mfg. Co.—"SCOTCH"

TAPE, FRICTION

Boston Woven Hose & Rubber Co., Div. of American Biltrite Rubber Co.
Continental Rubber Works
The Dayton Rubber Co.—"HOLE-FAST"
Goodall Rubber Co.
B. F. Goodrich Industrial Products Co.
Guyan Machy. Co.
Industrial Rubber Products Co. (Pa.)

Jenkins Bros.
Johns-Manville—"4-STAR"
Mosebach Electric & Supply Co.
National Electric Coil Co.
National Mine Service Co.
Okonite Co.
Plymouth Rubber Co., Inc.—"SLIPKNOT"
The Ruberoid Co.
United State Rubber Co.
West Virginia Armature Co.

TAPE, GLASS-CLOTH

Johns-Manville
National Electric Coil Co. — "MICA-GLAS"

TAPE, GLASS-CLOTH, COATED

Irvington Div. of Minnesota Mining & Mfg. Co.—"FIBRE-MAT"

TAPE, INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section—"V-C" "IRRATHENE," "MICAMAT"

TAPE, OZONE-RESISTANT

Plymouth Rubber Co., Inc. — "PLYMOZONE"

TAPE, PAPER

Minnesota Mining & Mfg. Co.—"SCOTCH"

TAPE, POLYETHYLENE

The Dayton Rubber Co.—"HOLFAST"

TAPE, RUBBER

Boston Woven Hose & Rubber Co., Div. of American Biltrite Rubber Co.
Continental Rubber Works
The Dayton Rubber Co.—"HOLFAST"
Goodall Rubber Co.
Jenkins Bros.
Johns-Manville
Mosebach Electric & Supply Co.
National Electric Coil Co.
National Mine Service Co.
Okonite Co.
Plymouth Rubber Co., Inc. — "P. R."
Quaker Rubber Div., H. K. Porter Co.
United States Rubber Co.
West Virginia Armature Co.

TAPE, VARNISHED-CAMBRIC

Irvington Div. of Minnesota Mining & Mfg. Co.
National Electric Coil Co.
Minnesota Mining & Mfg. Co.—"IRVINGTON," "IRV-O-FLATSEME," "IVI-BIND"

TAPE, VINYL PLASTIC

The Dayton Rubber Co.—"HOLFAST"

TAPE, VULCANIZING

American Mine Door Co.

TAPES, MEASURING

Charles Bruning Co., Inc.
Disston Div., H. K. Porter Co., Inc.
Lufkin Rule Co.

TAPPERS, PORTABLE

Black & Decker Mfg. Co.

TAPS, CABLE & TROLLEY, FUSED

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Mining Machine Parts, Inc.—"MMP JABCO"
Mosebach Electric & Supply Co.
Ohio Brass Co.
Standard Devices Co.

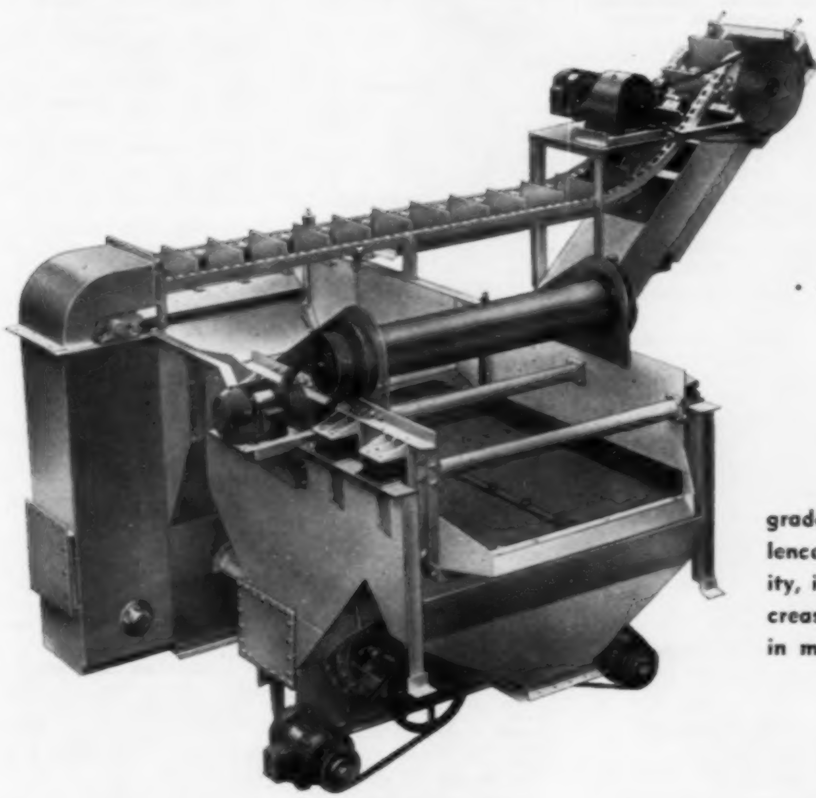
TARPAULINS

C. R. Daniels Co.
Fulton Bag & Cotton Mills

TELEPHONES, BATTERY

Crouse-Hinds Co.

PROVEN BY EXPERIENCE
The Fuel Process M Type Coal Washer



. . . an efficient washer
designed to lower costs and add to profits

This washer obtains
grade products of highest excellence both in appearance and quality, improves your product and increases profits by eliminating loss in marketable material in refuse.

INTEGRAL DRAIN SCREEN and IMPROVED FLOW SYSTEM provides

1. Lowest power in heavy media system.
2. Uniform volume and specific gravity of media.
3. No blocking of refuse compartments by near-gravity middlings.

GROSS GAIN OF $500 PER DAY Says User

"The Fuel Process Washer was purchased for our plant for two main reasons. First, to improve the overall product and for quality control. Second, and most important, to recover marketable material which was occurring in the refuse as a result of inherent inefficiency. . . . The overall product has been greatly improved and we now have positive quality control. The refuse data leaves little doubt that there is virtually no marketable material being lost from the heavy media washer.

"The inescapable conclusion is that with the Fuel Process Coal Washer there has been a marked improvement in our product with a gross gain in realization in excess of $500 per day." (Client's name on request.)

Write for complete details today. This fine product can earn money for your company, too.

FUEL PROCESS COMPANY

900 D STREET, P.O. BOX 8455, SOUTH CHARLESTON, W. VA.

TELEPHONES, SOUND-POWERED

Crouse-Hinds Co.
Mining Progress, Inc.

TELEPHONES, TROLLEY

Femco, Inc.
Industrial Physics & Electronics Co.

TELEVISION SYSTEMS

Diamond Power Specialty Co.—"UTILISCOPE," "UTILI-VUE"

TEMPERATURE INDICATORS, CONTROLLERS

B-I-F Industries, Inc.—"CHRONOFLO"
The Bristol Co.—"BRISTOL'S"
Fischer & Porter Co.
Fisher Scientific Co.
Foxboro Co.
General Electric Co. Apparatus Sales Div.
Hays Corp.
Minneapolis-Honeywell Regulator Co., Industrial Division "GUARDSMAN-VERI-TELL"
West Instrument Corp.—
Westinghouse Electric Corp.

TERMINATORS

Delta-Star Electric Div., H. K. Porter Co., (Delaware)

TEST STANDS, HYDRAULIC

Fischer & Porter Co.
Schroeder Brothers Corp.—"UNIVERSAL"
Vickers Incorporated

TESTERS, CARBON MONOXIDE

Mine Safety Appliances Co.

TESTERS, INSULATION

Electrical Distributors Co.
Ideal Industries, Inc.
Martindale Electric Co.

TESTERS, INSULATORS

I-T-E Circuit Breaker Co.

TESTERS, PORTABLE HYDRAULIC

Schroeder Brothers Corp.—"PT-50-B"

TESTERS, RAIL-BOND

Mosebach Electric & Supply Co.
Ohio Brass Co.

TESTERS, VOLTAGE

Fisher Scientific Co.
General Electric Co., Apparatus Sales Div.
Holub Industries, Inc.
I-T-E Circuit Breaker Co.
Ideal Industries, Inc.
Martindale Electric Co.
Westinghouse Electric Corp.

THEODOLITES

W. & L. E. Gurley

THEODOLITES, OPTICAL MINING

Kern Instruments, Inc.

THERMOCOUPLES

The Bristol Co.—"BRISTOL'S"
Foxboro Co.
General Electric Co., Apparatus Sales Div.
Minneapolis-Honeywell Regulator Co., Industrial Division
West Instrument Corp.

THROTTLE CONTROLS

Link-Belt Speeder Corp.—"SPEED-O-TROL"

THICKENERS

American Well Works
Denver Equipment Co.—"DENVER-STANDARD," "DENVER HEAVY-DUTY AUTOMATIC"
Dorr-Oliver, Inc.
Eimco Corp.
Hardinge Co., Inc.
Link-Belt Co., Dept. CAMGL-58
Morse Bros. Machinery Co.
Peterson Filters & Engineering Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Western Machinery Co.—"WEMCO"

THICKENING, STABILIZING, SUSPENDING AGENTS

B. F. Goodrich Chemical Co.—"GOOD-RITE CARBOPAL 934"

THINNERS, ELECTRIC INSULATING

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Secton

TIES, CROSS, SWITCH

Republic Creosoting Co.

TIMBER—See also Roof Supports, Yielding Arch

TIMBER, ALUMINUM

Reynolds Metals Co.

TIMBER, PRESSURE-CREOSOTED

Koppers Co., Inc. Wood Preserving Div.

TIMBER, TREATED

Koppers Co., Inc., Wood-preserving Div.—"WOLMANIZED"
Osmose Wood Preserving Co.

TIMBER, TREATED, UNTREATED

T. J. Moss Tie Co.

TIMBER, YIELDING STEEL PROPS

Mining Progress, Inc.
T. J. Moss Tie Co.

TIMBER FRAMERS

Denver Equipment Co.—"DENVER"
Stearns-Roger Mfg. Co.

TIMBER PULLERS

Penn Machine Co.
Templeton, Kenly & Co.—"SIMPLEX"

TIMBER-TREATING MATERIALS

Darworth, Inc., Chemical Products Div.—"CUPRINOL"
The Dow Chemical Co.
Monsanto Chemical Co., Organic Chemicals Div.
T. J. Moss Tie Co.
Osmose Wood Preserving Co.—"OSMOSALTS, OSMOPLASTICS, M-T-M"

TIMBERING MACHINES

Goodman Mfg. Co.
Ruger Equipment, Inc. "RUGER TIMBERLIFT"

TIMERS, MERCURY

Durakool, Inc.
Joy Mfg. Co.

TIRE RECAPPING, REPAIRING, EARTHMOVER

Carolina Tire Co.

TIRES, EARTHMOVER, ON THE JOB SERVICE

Carolina Tire Co.

TIRES, MINE

Mitchell Industrial Tire, Inc.—"MITCO TROUBLE FREE"

TIRES, RUBBER

The Dayton Rubber Co.—"THOROBRED"
The Gates Rubber Co. Sales Div., Inc.
B. F. Goodrich Tire Co., A Div. of The B. F. Goodrich Co.
Goodyear Tire & Rubber Co.
United States Rubber Co.
W. Va. Belt Repairs, Inc.—"MITCO INDUSTRIAL"

TIRES, STEEL

National Mine Service Co.
Bertrand P. Tracy Co.

TIRES, STEEL TURNING

Leman Machine Co.

TOOLS, ELECTRICAL-CONNECTOR

Burndy Corp.—"HYTOOLS," "HYPRESSES"
Erico Products, Inc.—"CAD-WELD"
Joy Mfg. Co.

TOOLS, HAND

Ampco Metal, Inc.
Guyan Machy. Co.—"PROTO," "CHALLENGER"
Proto Tool Co., Div. of Pendleton Tool Industries, Inc.

TOOLS, MECHANICS

Bearings, Inc.
Disston Div., H. K. Porter Co., Inc.
Gensco Tools Div., General Steel Warehouse Co., Inc.
Sanp-on Tools Corp.

TOOLS, PORTABLE, AIR

Chicago Pneumatic Tool Co.
Ensign Electric & Mfg. Co.
Gardner-Denver Company
Ingersoll-Rand Co.
Joy Mfg. Co.
Le Roi Div., Westinghouse Air Brake Co.
Marathon Coal Bit Co., Inc.—"BUCKEYE"
Penn Machine Co.
Schramm, Inc.
Schroeder Brothers Corp.
Sanp-on Tools Corp.
Thor Power Tool Co.
Worthington Corp.

TOOLS, PORTABLE, ELECTRICAL

Black & Decker Mfg. Co.
Chicago Pneumatic Tool Co.
Ensign Electric & Mfg. Co.
Ingersoll-Rand Co.
Martindale Electric Co.
Penn Machine Co.
Joseph T. Ryerson & Son, Inc.
Snap-on Tools Corp.
Syntron Co.
Thor Power Tool Co.

TOOLS, POWDER-POWERED

Mine Safety Appliances Co.—"VELOCITY-POWER"
Remington Arms Co., Inc.—"REMINGTON INDUSTRIAL KILN GUN," "REMINGTON STUD DRIVER"

TOOLS, TRACK

The Aldon Co.
L. B. Foster Co.
Gibraltar Equipment & Mfg. Co.
The Leetonia Tool Co.

TORQUE CONVERTERS

Clark Equip. Co., Automotive Div. — "CLARK-TORCON"
National Supply Company—"NATIONAL"
Transmission and Axle Div., Rockwell-Standard Corp..
Twin Disc Clutch Co.

TORQUE TESTERS

The Fafnir Bearing Co.

TOWBOATS

Dravo Corp.
Marietta Mfg. Co.

TOWERS, BARGE-UNLOADING

Dravo Corp.
Heyl & Patterson, Inc.
Link-Belt Co., Dept. CAMGL-58
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Stephens-Adamson Mfg. Co.

TOWERS, HYDRAULIC

Mobile Aerial Towers, Inc. — "HI-RANGER"

TOWERS, LOADING

Link-Belt Co., Dept. CAMGL-58

TRACK CLEANERS

American Mine Door Co. — "CANTON"

TRACK SHOES, POWER SHOVEL

American Steel Foundries — "WEARPACT"

TRACKWORK

H. K. Porter Co., Connors Steel Div.

TRACTOR-COMPRESSOR UNITS

Gardner-Denver Company
Le Roi Div., Westinghouse Air Brake Co.—"TRACTAIR"

TRACTORS, DOZER

Clark Equipment Co., Construction Machinery Div. — "MICHIGAN"

TRACTOR GROUSER BARS

American Brake Shoe Co., Amsco Div.—"AMSCO"

TRACTOR GROUSERS

American Steel Foundries — "WEARPACT"

TRACTOR POWER CONTROL UNITS

Le Tourneau-Westinghouse Co.

TRACTOR RAIL & GROUZERS, MANGANESE

Kensington Steel, Div. of Poor & Co.

TRACTOR SPROCKET RIMS, MANGANESE

Kensington Steel, Div. of Poor & Co.

TRACTORS, CRAWLER

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
J. I. Case Co. — "CASE-TERRATRAC"
Caterpillar Tractor Co.
Diesel Energy Corp.
Eimco Corp.
General Motors Corp., Euclid Division
International Harvester Co., Construction Equipment Div.
The Oliver Corp. — "OLIVER"

TRACTORS, CRAWLER, UNDERGROUND

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Caterpillar Tractor Co.
Eimco Corp.
International Harvester Co., Construction Equipment Div.
Joy Mfg. Co.

TRACTORS, RUBBER-TIRED MINE

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Caterpillar Tractor Co.
Fred's Welding Service
Kersey Manufacturing Co., Inc.
Motor Exchange and Supply Co.

TRACTORS, TRUCK HAULAGE

The Four Wheel Drive Auto Co.
Henrickson Mfg. Co.
International Harvester Co., Construction Equipment Div.
KW Dart Truck Co.
LeTourneau-Westinghouse Co. —"TOURNAPULL"
Mack Trucks, Inc.
Reo Div., The White Motor Co.

TRACTORS, WHEELED

Allis-Chalmers Mfg. Co., Con-

WEMCO EQUIPMENT

struction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
J. I. Case Co.—"CASE"
Caterpillar Tractor Co.
Diesel Energy Corp.
The Four Wheel Drive Auto Co.—"BLUE OX"
The Frank G. Hough Co.
International Harvester Co., Construction Equipment Div.
LeTourneau-Westinghouse Co. —"TOURNATRACTOR TWIN C"
The Oliver Corp. — "OLIVER"

TRAILER AXLES

Clark Equip. Co., Automotive Div. — "CLARK"
Winter-Weiss Co.

TRAILER BODIES

Baughman Mfg. Co., Inc.
Perfection Steel Body Co.
Winter-Weiss Co.

TRAILERS, FULL, REAR-DUMP

Galion Allsteel Body Co.

TRAILERS, BOTTOM-DUMP

Athey Products Corp.
General Motors Corp, Euclid Division
Perfection Steel Body Co.
Sanford Day Iron Works, Inc.
Truck Engineering Corp.

TRAILERS, SIDE-DUMP

Athey Products Corp.
Perfection Steel Body Co.
Truck Engineering Corp.

TRAILERS, REAR-DUMP

Athey Products Corp.
Hercules Steel Products Co.
Perfection Steel Body Co.
Truck Engineering Corp.

TRAILERS, SEMI, BOTTOM-DUMP

Hockensmith Corp.
K. W. Dart Truck Co.
Le Tourneau-Westinghouse Co. —"TOURNAPULL"
Marion Metal Products Co.
Perfection Steel Body Co.
Truck Engineering Corp.

TRAILERS, SEMI, SIDE-DUMP

Baughman Mfg. Co., Inc.—"HYDRAULIC"
Hockensmith Corp.
Le Tourneau-Westinghouse Co. —"TOURNAPULL"
Marion Metal Products Co.
Perfection Steel Body Co.
Truck Engineering Corp.

TRAILERS, SEMI, REAR-DUMP

Galion Allsteel Body Co.
Hercules Powder Co.
Hockensmith Corp.
Le Tourneau-Westinghouse Co. —"TOURNAPULL"
Marion Metal Products Co.
Perfection Steel Body Co.
Truck Engineering Corp.

TRANSFER CASES

Clark Equip. Co., Automotive Div.
The Four Wheel Drive Auto Co.
Timken Detroit Axle a Div., Rockwell Spring & Axle Co.

TRANSFORMERS, CONTROL, INSTRUMENT

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
The Bristol Co.
General Electric Co., Apparatus Sales Div.
Hevi-Duty Electric Co.
Wagner Electric Corp.
Westinghouse Electric Corp.

TRANSFORMERS, POWER

Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Atkinson Armature Works
General Electric Co., Apparatus Sales Div.
F. R. Hannon & Sons—"HANCO"
Hevi-Duty Electric Co.
I-T-E Circuit Breaker Co.
Kuhlman Elec. Co.
Herbert S. Littlewood
Moloney Electric Co.
Morse Bros. Machinery Co.
Mosebach Electric & Suppy Co.
National Mine Service Co.
Wagner Electric Corp.
Westinghouse Electric Corp.

TRANSITS, ENGINEER'S

Charles Bruning Co., Inc.
Gurley, W. & L. E.

TRANSMISSIONS

Transmission and Axle Div., Rockwell-Standard Corp.

TRANSMISIONS, AUTOMOTIVE

Allison Div., General Motors Corp.—"TORQMATIC"
Clark Equip. Co., Automotive Div.—"CLARK"
The Four Wheel Drive Auto Co.
Fuller Mfg. Co.

TRANSMISSIONS, INDUSTRIAL

Fuller Mfg. Co.

TRANSMISSIONS, REVERSING

The Snow-Nabstedt Gear Corp.

TRANSMISSIONS, VARIABLE SPEED

Link-Belt Co., Dept. CAMGL-58—"P.I.V."
Reeves Pulley Co., Div. The Reliance Electric & Engineering Co. "VARI-SPEED"

TREADPLATE, ALUMINUM

Aluminum Co. of America

TREADPLATE, ALUMINUM, ABRASIVE

Aluminum Co. of America

TRIP FEEDER-RETARDERS

The Nolan Co.

TRIP HOLDERS

The Nolan Co.

TRIP LAMPS

Concordia Electric Co.—"CEAG"
General Electric Co., Lamp Div. —"GENERAL ELECTRIC"
Mine Safety Appliances Co.—"EDISON R-4"
National Mine Service Co.

TROLLEY CLAMPS

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Mosebach Electric & Supply Co.
Ohio Brass Co.

TROLLEY-CONTACT DEVICES, SLIDE-OPERATED

Cheatham Electric Switching Device Co.
Nachod & U. S. Signal Co.

TROLLEY, CONVEYOR

Link-Belt Co., Dept. CAMGL-58

TROLLEY FROGS

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.

TROLLEY FROGS, ELECTRIC

Cheatham Elec. Switching Device Co.
Ohio Brass Co.

TROLLEY GUARDS

Ensign Electric & Mfg. Co.
John Flocker & Co.
B. F. Goodrich Industrial Products Co.—"KOROSEAL"
Guyan Machy. Co.—"VISI-GARD"
Mosebach Electric & Supply Co.
National Mine Service Co.
Mine Safety Appliances Co.
Ohio Brass Co.
Raybestos Manhattan, Inc. Manhattan Rubber Div.
United States Rubber Co.

TROLLEY HANGERS

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Mosebach Electric & Supply Co.
Ohio Brass Co.

TROLLEY HARPS, SHOES, SLIDERS

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Jeffrey Mfg. Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.
Ohio Carbon Co.

TROLLEY, LINE MATERIAL

National Mine Service Co.

TROLLEY POLES, WOOD

Duquesne Mine Supply Co.
Flood City Brass & Electric Co.
J. V. Hammond Co.

TROLLEY-SHOE, CONTACTORS

American Mine Door Co.
Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.
Ohio Carbon Co.

TROLLEY SIGNAL SYSTEMS

American Mine Door Co.
Nachod & U. S. Signal Co.

TROLLEY SPLICES

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.
West Virginia Armature Co.

TROLLEY SYSTEMS

The Elreco Corp.—"ELRECO"
Ohio Brass Co.

TROLLEY TAPS—See Taps, Cable & Trolley

TROLLEY WHEELS

Duquesne Mine Supply Co.
The Elreco Corp.—"ELRECO"
Flood City Brass & Electric Co.
Jeffrey Mfg. Co.
Mosebach Electric & Supply Co.
Ohio Brass Co.
Ohio Carbon Co.
Pittsburgh Gear Co.

TROLLEY WHEELS, CONVEYOR

Link-Belt Co., Dept. CAMGL-58

TROLLEY-WIRE CONDITIONERS

Ohio Brass Co.

TROLLEYS, I-BEAM

Coffing Hoist Div., Duff-Norton Co.

TROWELS

Disston Div., H. K. Porter Co., Inc.

TRUCK AXLES

Eaton Mfg. Co., Axle Div.
Ford Div. of Ford Motor Co.
The Four Wheel Drive Auto Co.

TRUCK AXLES, DRIVING

Ford Div. of Ford Motor Co.
The Four Wheel Drive Auto Co.

TRUCK BODIES

Baughman Mfg. Co., Inc.
Ford Div. of Ford Motor Co.
Galion Allsteel Body Co.
Gar Wood Industries, Inc.
Hercules Steel Products Co.
Hockensmith Corp. — "PENN"
Perfection Steel Body Co.

TRUCK BODY FLOORS, ALUMINUM

Revere Copper & Brass, Inc.

TRUCK BOGIES

Clark Equip. Co., Automotive Div. — "CLARK"
Ford Div. of Ford Motor Co.
The Four Wheel Drive Auto Co.
Hendrickson Mfg. Co.

TRUCK DRIVES, TANDEM-AXLE

Clark Equip. Co., Automotive Div. — "CLARK"
Eaton Mfg. Co., Axle Div.
Ford Div. of Ford Motor Co.
Hendrickson Mfg. Co.

TRUCK HUBS, LOCKING

Warn Mfg. Co. — "LOCK-O-MATIC"

TRUCK SAFETY STEPS

E. D. Bullard Co.

TRUCKS, AUTOMOTIVE

Chevrolet Motor Div.
Dodge Div., Chrysler Corp. — "DODGE POWER GIANTS"
Ford Div. of Ford Motor Co.
The Four Wheel Drive Auto Co.
Hendrickson Mfg. Co.
International Harvester Co., Construction Equipment Div.
International Harvester Co., Motor Truck Div.—"INTERNATIONAL"
Koehring Div. of Koehring Co.
Mack Trucks, Inc.
Reo Div., The White Motor Co.

TRUCKS, FORK LIFT

Hyster Co.—"HYSTER," "SPACE SAVER," "MONOMAST"

TRUCK, MINE-CAR

American Car & Foundry Div., ACF Industries, Inc.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
National Malleable & Steel Castings Co.—"NATIONAL NC-1"
Sanford Day Iron Works, Inc.

TRUCKS, MINE-LOCOMOTIVE

Penn Machine Co.

TRUCKS, OFF-HIGHWAY

General Motors Corp., Euclid Div.
International Harvester Co., Construction Equipment Div. —"PAYHAULER"
KW Dart Truck Co.

TUBING AND TUBE FITTINGS

Anchor Coupling Co., Inc.
Parker Fittings & Hose Div., Parker-Hannifin Corp. — "FERULOK," "TRIPLE-LOK"

TUBING, ELECTRICAL MECHANICAL

Youngstown Sheet & Tube Co.

TUBING, FLEXIBLE-METAL

Cobra Metal Hose Div., DK Mfg. Co.

TUBING, PLASTIC AND COATED

Irvington Div. of Minnesota Mining & Mfg. Co.

TUBING, SEAMLESS STEEL

National Tube Div., United States Steel Corp.—"USS
The Timken Roller Bearing Co.

TUBING, STAINLESS-STEEL

Crucible Steel Co. of America
National Tube Div., United States Steel Corp.—"USS Shelby"

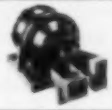
WEMCO EQUIPMENT

FOR COAL CLEANING AND BENEFICIATION

HEAVY MEDIA SEPARATION

WEMCO MOBIL-MILL

A complete, pre-engineered, pre-fabricated HMS plant for profitable, premium coal production from first day of operation. Integrated design for rapid erection — and one man operation — even by inexperienced personnel. Answers ash reduction problems economically, profitably.



WEMCO DRUM SEPARATOR

Incorporated in Wemco Mobil-Mill for coal cleaning. Float material overflows; sink material is raised by lifters. Two compartment drums produce a true sink, true float and middling. Double drums make two separations.

WEMCO CONE SEPARATOR

For sharp separations where longer retention time is required in size range of 4 inch to approximately 10 mesh. Clean coal floats to the surface and overflows; sink material removed by airlift.

FLOTATION AND BENEFICIATION

WEMCO-FAGERGREN FLOTATION MACHINE

World standard for producing clean, low ash coal from fines. Large cell size; rotor-stator gives maximum aeration and recovery in shortest time and space. New air control for increased cleaning efficiency. Special feed boxes and pumper cells eliminate complicated pumping installations.

WEMCO AGITATOR-CONDITIONER

Mixes coal-water slurry with reagents to condition coal particle surfaces when necessary before flotation. Available in Wemco-Fagergren type and propeller type.

CLEANING AND HANDLING

WEMCO COAL SPIRAL

High capacity, low cost dewatering device for coal from ⅜ inch to 48 mesh. Also serves as classifier for slimes and fines, making sharp overflow separation at 35, 100 or other desired mesh size. An important use is for dewatering of wet screen underflows.

WEMCO HYDROSEPARATOR

Used for desliming fine coal ahead of flotation or tabling, and low-cost, efficient separation in minus 200 mesh range. Slimes overflow weir at low velocity. This prevents loss of desired plus 200 or finer mesh particles. Fine coal for flotation withdrawn from center of tank bottom.

PUMPING

WEMCO DIAPHRAGM PUMP

Withdraws continuous volume from thickener or hydroseparator underflows. Useful for feeding pulps at constant rates. Slow speed, reliable and easy to maintain.

WEMCO SAND PUMP

The universal pump for the coal and mining industries for heavy media circuits, fine coals, fine refuse and other abrasive pulps. Has a minimum of wearing parts. Designed for quick dis-assembly.

WEMCO VERTICAL PUMP

Also available in vertical style, which permits pumping from sump, vessel, launder or body of fluid without danger to bearings.

WEMCO TORQUE-FLOW PUMP

New principle incorporates recessed impeller, continuous, open passage. Permits pumping of large solids in slurry without clogging or degradation and with minimum wear.

WEMCO® **Western Machinery Company** 650 FIFTH STREET • SAN FRANCISCO 7, CALIFORNIA
and throughout the world

TUGBOATS
Wiley Manufacturing Co.

TURNBUCKLES
Bethlehem Steel Co.
Crosby Laughlin Div., American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
Duquesne Mine Supply Co.
Ohio Brass Co.
Joseph T. Ryerson & Son, Inc.
Upson-Walton Co.

TURNBUCKLES, INSULATED
The Elreco Corp.

TURNERS, WHEEL-FLANGE & TREAD
Transall, Inc.

UNLOADERS
Clyde Iron Works, Inc.
Link-Belt Co., Dept. CAMGL-58

USED EQUIPMENT (See Searchlight Advertising Section, this issue)

UTILITY TRUCKS, PERMISSIBLE RUBBER TIRED BATTERY
Kersey Mfg. Co., Inc.

VACUUM CLEANING, SWEEPING EQUIPMENT
Black & Decker Mfg. Co.
Ideal Industries, Inc.
Martindale Electric Co.

VALVE ACTUATORS, CYLINDER
Ledeen Mfg. Co.

VALVE RECONDITIONING
John Flocker & Co.

VALVE REFACERS & GRINDERS
Black & Decker Mfg. Co.

VALVES
M. Glosser & Sons, Inc.

VALVES, ANGLE
Detroit Controls Div., American Radiator & Standard Sanitary Corp., D. T. Williams Valves
Jenkins Bros.
R-P&C Valve Div., American Chain & Cable Co., Inc.

VALVES, ANGLE & Y
The Duriron Co., Inc.
Electric Steel Foundry Co.
The Fairbanks Co.
Homestead Valve Mfg. Co.
Midland Pipe & Supply Co.
Walworth Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, AUTOMATIC, FULL FLOW, QUICK OPENING AND SHUTOFF
Copous Engineering Corp.—"SENTRY"

VALVES, AIR
The Lunkenheimer Co.—"LUNKENHEIMER"
Schroeder Brothers Corp.

VALVES, BUTTERFLY
S. P. Kinney Engineers, Inc.

VALVES, CHECK
Allen-Sherman-Hoff Pump Co.—"FLEX-CHECK," "RUBBER LINED"
Barrett, Haentjens & Co.
Crane Co.
Detroit Controls Div., American Radiator & Standard Sanitary Corp., D. T. Williams Valves
Electric Steel Foundry Co.
The Fairbanks Co.
Farris Flexible Valve Corp.—"FLEX VALVE," "SUPER SEAL"
Goyne Pump Co.
Jenkins Bros.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc. "LUDLOW," "RENSSE/LAER"
The Lunkenheimer Co.—"FERRENEWO," "N-M-D," "RENEWO"
Midland Pipe & Supply Co.
Ohio Brass Co.
Osmose Wood Preserving Co.—"TECHNOCHECK"
R-P & C Valve Div., American Chain & Cable Co., Inc.
Schroeder Brothers Corp.
Walworth Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, COMPRESSED-AIR
A. W. Cash Valve Mfg. Corp.
Clark Controller Co.
The Fairbanks Co.
Homestead Valve Mfg. Co.
C. B. Hunt & Son, Inc.—"QUICK-AS-WINK"
Jenkins Bros.
Hose Accessories Co.
Pennsylvania Pump & Compressor Co.—"AIRCHECK," "GASCHECK"
Schroeder Brothers Corp.
Walworth Co.

VALVES, COMPRESSED AIR UNLOADING
R. Conrader Co.—"CONRADER"

VALVES, CORROSION-RESISTANT
The Duriron Co., Inc.
Electric Steel Foundry Co.
Homestead Valve Mfg. Co.
Ladish Co.

VALVES, CROSS
The Lunkenheimer Co.—"LUNKENHEIMER"

VALVES, DIAPHRAGM
The Bristol Co.—"SYNCHRO-VALVES"
A. W. Cash Co.
A. W. Cash Valve Mfg. Corp.
The Duriron Co., Inc.
Fischer & Porter Co.
Foxboro Co.
Grinnell Co.—"GRINNELL-SAUNDERS"
Minneapolis-Honeywell Regulator Co., Industrial Division
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, FLOAT
Fischer & Porter Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, FOOT
Crane Co.
Flood City Brass & Electric Co.
Ledeen Mfg. Co.
Ludlow Valve Mfg. Co., Inc.—"LUDLOW"
Midland Pipe & Supply Co.
Walworth Co.

VALVES, 4-WAY & 3-WAY
Ledeen, Inc.

VALVES, GATE
American Brake Shoe Co., Amsco Div.—"AMSCO"
American Brake Shoe Co., National Bearing Div.
Crane Co.
Detroit Controls Div., American Radiator & Standard Sanitary Corp. D. T. Williams Valves
Electric Steel Foundry Co.
The Fairbanks Co.
Fischer & Porter Co.
Guyan Machy. Co.
Jenkins Bros.
Kennedy Valve Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Ludlow Valve Mfg. Co., Inc.—"LUDLOW," "RENSSE-LAER"
The Lunkenheimer Co.—"BREECH-LOCK," "CAUSUL," "KING-CLIP"
McNally-Pittsburg Mfg. Corp.
Midland Pipe & Supply Co.
Ohio Brass Co.
R-P & C Valve Div., American Chain & Cable Co., Inc.
Stephens-Adamson Mfg. Co. — "TWISTITE"
Walworth Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, GATE, REPAIRED
Leman Machine Co.

VALVES, GLOBE
Crane Co.
Detroit Controls Div., American Radiator & Standard Sanitary Corp., D. T. Williams Valves
Electric Steel Foundry Co.
The Fairbanks Co.
Guyan Machy. Co.
Jenkins Bros.
Kennedy Valve Mfg. Co.
The Lunkenheimer Co.—"FERRENEWO," "LQ600" "N-M-D," "RENEWO"
McNally-Pittsburg Mfg. Corp.
Midland Pipe & Supply Co.
Ohio Brass Co.
R-P & C Valve Div. American Chain & Cable Co., Inc.
Walworth Co.
J. A. Zurn Mfg. Div., Zurn Industries, Inc. — "ZURN"

VALVES, GLOBE, REPAIRED
Leman Machine Co.

VALVES, HYDRAULICALLY OPERATED
Ludlow Valve Mfg. Co., Inc.

VALVES, LUBRICATED
Homestead Valve Mfg. Co.
Walworth Co.

VALVES, MOTOR-OPERATED
The Bristol Co.
Convair
Electric Steel Foundry Co.
Farris Flexible Valve Corp. — "FLEX VALVE," "SUPER SEAL"
Fischer & Porter Co.
Foxboro Co.
Homestead Valve Mfg. Co.
Kennedy Valve Mfg. Co.
S. P Kinney Engineers, Inc.
Ludlow Valve Mfg. Co., Inc.—"LUDLOW," "RENSSE-LAER"
Midland Pipe & Supply Co.
Minneapolis—Honeywell Regulator Co., Industrial Division
R-P & C Valve Div., American Chain & Cable Co., Inc.
Rockwell Mfg. Co.—"ROCK-WELL-NORDSTROM"
Walworth Co.
Western Precipitation Corp. — "TYPE R-1," "FLOATING-SEAL"
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, NEEDLE
Detroit Controls Div., American Radiator & Standard Sanitary Corp. D. T. Williams Valves
The Fairbanks Co.
Midland Pipe & Supply Co.
Ohio Brass Co.
R-P & C Valve Div American Chain & Cable Co. Inc,.
Schroeder Brothers Corp.
Walworth Co.

VALVES, ORIFICE
Fairmont Machinery Co.

VALVES, PINCH
The Daniels Co. Contractors Inc.
Farris Flexible Valve Corp.—"FLEX VALVE" "SUPER SEAL"
Linatex Corp of America
Red Jacket Co. Inc. — "RED JACKET"

VALVES, PLASTIC
The Lunkenheimer Co. — "LUNCOR"

VALVES, PLUG
Ampco Metal, Inc.
American Car & Foundry Div., ACF Industries, Inc.
Barrett, Haentjens & Co.
Convair
The Duriron Co., Inc.
Homestead Valve Mfg. Co.
S. P. Kinney Engineers, Inc.
Ludlow Valve Mfg. Co., Inc—"LUDLOW"
McNally-Pittsburg Mfg. Corp.
Midland Pipe & Supply Co.
Rockwell Mfg. Co. — "ROCK-WELL," "NORDSTROM"
J. A. Zurn Mfg. Div., Zurn Industries, Inc.—"ZURN"

VALVES, POWER-OPERATED
Ledeen Mfg. Co.

VALVES, PUMP
American Brake Shoe Co., Amsco Div.—"AMSCO"
Anchor Packing Co.
Electric Steel Foundry Co.

VALVES, SAFETY
A. W. Cash Valve Mfg. Corp.

VALVES, SOLENOID, MANUAL
Barksdale Valves

VALVES, STAINLESS-STEEL
Electric Steel Foundry Co.

VARNISHES, INSULATING
Dow Corning Corp.
E. I. du Pont de Nemours & Co., Inc.
General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section — "GLYPTAL"
Jeffrey Mfg. Co.
Martindale Electric Co.
Minnesota Mining & Mfg. Co. —"IRVINGTON," "HARVEL"
National Mine Service Co.
Pennsylvania Electric Coil Corp.

VENTILATING, TUBING
American Brattice Cloth Corp.
Bemis Bro. Bag Co.—"FLEXIPIPE"
Flexaust Co.—"PORTOVENT"

VENTILATION SURVEYING EQUIPMENT
American Paulin System — "MICRO," "TERRA"

VIBRATION ABSORBERS
Cobra Metal Hose, Div. D K Mfg. Co.

VIBRATION DAMPERS, RUBBER
Fluor Products Co.
Goodyear Tire & Rubber Co.
Raybestos Manhattan, Inc. Manhattan Rubber Div.

VIBRATION MEASUREMENT, BLASTING
W. F. Sprengnether Instrument Co., Inc.
Vibration Measurement Engineers, Inc.—"SEISMOLOG"

VIBRATORS, BIN & HOPPER
The Branford Co.—"BRAN-FORD"
Cleveland Vibrator Co.
Eriez Manufacturing Co.
Hewitt-Robins Incorporated
Martin Engineering Co.—"VIBROLATOR"
National Air Vibrator Co.
Syntron Co.—"PULSATING MAGNET"
W. S. Tyler Co.—"TY-SPEED"
Viber Co.—"AIROVIBER," "VIBERLEC," "MODEL PX"

VIBRATORS, CHUTE
The Branford Co.—"BRAN-FORD"

Cleveland Vibrator Co.
Martin Engineering Co.—"VIBROLATOR"
National Air Vibrator Co.
Syntron Co.—"PULSATING MAGNET"
W. S. Tyler Co.
Viber Co.—"AIRO VIBER," "VIBERLEC," "MODEL PX"

VIBRATORS, FREIGHT CAR

Martin Engineering Co.

VOLTMETERS, INDICATING

General Electric Co., Apparatus Sales Div.
Martindale Electric Co.
Westinghouse Electric Corp.

VOLMETERS, RECORDING

The Bristol Co.—"BRISTOL'S"
General Electric Co., Apparatus Sales Div.
Westinghouse Electric Corp.

WAGONS, HAULING

Allis-Chalmers Mfg. Co., Construction Machinery Div.
Allis-Chalmers Mfg. Co., Industrial Equipment Div.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

WALLS, SUSPENDED FURNACE

Bigelow-Liptak Corp.

WAREHOUSE DOOR PROTECTION

Union Switch & Signal Div. Westinghouse Air Brake Co.

WARNING SIGNALS

American Mine Door Co.
Crouse-Hinds Co.

WARNING SIGNALS, FLASHING

Nachod & U. S. Signal Co.

WASHABILITY TESTS

The Daniels Co. Contractors, Inc.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Warner Laboratories, Inc.

WASHERS, AIR

American Blower, Div. of American-Standard

WASHERS, CALCIUM-CHLORIDE

Fuel Process Co.—"BELKNAP"
Kanawha Mfg. Co.

WASHERS, COAL

Link-Belt Co., Dept. CAMGL-58— "LINK-BELT," "AIR-PULSATED," "AEROPOISE"
Ore Reclamation Co.—"O.R.C."

WASHERS, COAL SPIRAL

Western Machinery Co.—"WEMCO"

WASHERS, HEAVY-MEDIA

The Daniels Co., Contractors, Inc.—"DMS"
Nelson L. Davis Co.—"NELDCO"
Fairmont Machinery Co.
Fuel Process Co.—"M-TYPE"
Hewitt-Robins Incorporated,—"ELIPTEX"
Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58—"FLOAT-SINK"
McNally-Pittsburg Mfg. Corp.—"McNALLY TROMP"
The Ore & Chemical Corp.—"OCC VESSEL"
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Smith Engineering Works
Western Machinery Co.—"WEMCO"
Wilmot Engineering Co.

WASHERS, JIG

Jeffrey Mfg. Co.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
McNally-Pittsburg Mfg. Corp. —"McNALLY MOGUL," "McNALLY GIANT," "McNALLY NORTON," "McNALLY AUTOMATIC," FINE COAL WASHER"
Ore Reclamation Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Wilmot Engineering Co.

WASHERS, LAUNDER, TROUGH

The Daniels Co., Contractors, Inc.—"DMS"
Link-Belt Co., Dept. CAMGL-58
K. Prins & Associates—"PRINS"
Roberts & Schaefer Co., Sub. Thompson-Starrett Co. Inc.
Wilmot Engineering Co.

WASHERS, JIG, FINE-COAL

McNally-Pittsburg Mfg. Corp.

WASHERS, SAND-FLOTATION

Fairmont Machinery Co.
Universal Road Machinery Co.—"RELIANCE"

WASHERS, SCREW

Eagle Iron Works
Link-Belt Co., Dept. CAMGL-58
McLanahan & Stone Corp.

WASHERS, UPWARD-CURRENT

Eagle Iron Works
Fuel Process Co.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.
Wilmot Engineering Co.

WATER CLARIFICATION SYSTEMS

Bird Machine Co.
The Daniels Co., Contractors, Inc.
Dorr-Oliver, Inc.
Heyl & Patterson, Inc.
Kanawha Mfg. Co.
McNally-Pittsburg Mfg. Corp.
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

WATER NEUTRALIZERS

American Minechem Co.
American Well Works
The Permutit Co., a Div. of Pfaudler Permutit Inc.

WATER-RECLAMATION SYSTEMS

Bird Machine Co.
Dorr-Oliver, Inc.
Kanawha Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
The Permutit Co., a Div. of Pfaudler Permutit Inc.
K. Prins & Associates
Roberts & Schaefer Co., Sub. Thompson-Starrett Co., Inc.

WATER REPELLENTS

American Minechem Co.
Dow Corning Corp.
E. I. du Pont de Nemours & Co., Inc.
Stonhard Co.—"STONSEAL"
Sika Chemical Corp.—"SIKA-PEL"

WATER SOFTENERS, DEMINERALIZERS

The Permutit Co.

WATER SYSTEMS, DOMESTIC

Barnes Mfg. Co.

WATER-TREATMENT EQUIPMENT

B-I-F Industries, Inc.
Shirley Machine Co.

WATTMETERS, CLAMP-ON

Martindale Electric Co.

WEARING PLATES

American Brake Shoe Co., Amsco Div.

WEDGE BARS, TOOTH REPOINTING

American Brake Shoe Co., Amsco Div.
Stulz-Sickles Co.—"MANGANAL"

WEDGE BARS, TOOTH REPOINTING, MANGANESE

Kensington Steel, Div. of Poor & Co.

WEDGES, CONE

The Leetonia Tool Co.

WELDERS, ARC

Air Reduction Sales Co. A Div. of Air Reduction Co., Inc.
Caterpillar Tractor Co.
Flood City Brass & Electric Co.
Harnischfeger Corp.
Hobart Bros. Co.
The Lincoln Electric Co.—"SHIELD-ARC," "IDEAL-ARC," "FLEET-WELDER," "LINCOLNWELD," "LINC-WELDER," "INTERTARC," "INNER-SHIELD," "SQUIRT WELDER"
Marathon Coal Bit Co., Inc.—"AIRCO"
Metal & Thermit Corp. — "M & T"
Mosebach Electric & Supply Co.
Penn Machine Co.
Westinghouse Electric Corp.

WELDERS, RAIL BONDING

Erico Products, Inc. — "CADWELD"
Flood City Brass & Electric Co.
Guyan Machy. Co.—"GUYAN"
Ohio Brass Co.
Penn Machine Co.
The Post Glover Electric Co.—"P-G"

WELDERS, RECTIFIER

Harnischfeger Corp.

WELDERS, SEMI-AUTOMATIC

Alloy Rods Co. — "WEAR-O-MATIC WIRE FEED"

WELDERS, TRANSFORMER

Harnischfeger Corp.

WELDING CABLE

Collyer Insulated Wire Co.
Cornish Wire Co., Inc.
Gar Wood Industries, Inc.
General Cable Corp.
General Electric Co., Construction Materials Div.
Guyan Machy. Co.
Hobart Bros. Co.
Kaiser Aluminum & Chemical Sales, Inc.
The Lincoln Electric Co. — "STABLE-ARC," "LINCOLNDUCTOR"
Marathon Coal Bit Co., Inc.—"AIRCO"
National Electric Products Co.
John A. Roebling's Sons Corp., Sub. Colorado Fuel & Iron Corp.
Rome Cable Corp.—"ROME 60"
Tweco Products, Inc. — "TWECO LITE"

WELDING CARBON PRODUCTS

Helwig Co.
Marathon Coal Bit Co., Inc.—"AIRCO"
National Carbon Co., Div. of Union Carbide Corp.
Ohio Carbon Co.
Stackpole Carbon Co.

WELDING, CUTTING TORCHES, OUTFITS

Air Reduction Sales Co. A Div. of Air Reduction Co., Inc.
General Scientific Equipment Co. — "GS"
Marathon Coal Bit Co., Inc.—"AIRCO"

WELDING-ELECTRODE HOLDERS

Air Reduction Sales Co. A Div. of Air Reduction Co., Inc.
Erico Products, Inc. — "CADDY"
Guyan Machy. Co.
Hobart Bros. Co.
The Lincoln Electric Co. — "COOLTONG," "INS," "HT," "T"
Mosebach Electric & Supply Co.
Tweco Products, Inc. — "TWECOTONG"

WELDING ELECTRODES AND GAS WELDING WIRE

Page Steel & Wire Div., American Chain & Cable Co., Inc.

WELDING ELECTRODES

Alloy Rods Co.—"ATOM ARC "ARCALOG," "TOOL ARC," "NICKEL ARC," "BRONZE ARC"
Ampco Metal, Inc.—"AMPCO TRODE," "PHOS-TRODE," "AMPCO-WELD"
Crucible Steel Co. of America
Eutectic Welding Alloys Corp.—"BRONZOCHROM" "CASTOLIN EUTECTIC," "CUT TRODE," "EUTE-CHROM," "EUTEC-ROD," "EUTECTIC LOW TEMPERATURE WELDING ALLOYS," 'EUTEC STAIN-ROD," "FLOTECTIC," "FRIGID ARC," "EUTEC "HANDOMATIC," "STEEL-TECTIC," "TIN WELD," "EUTECTOR FLUX,' "EUTECTRODE," "EUTECTOMASK," "EUTEC SILVER WELD," "EUTEC STAINTRODE," "ALUTIN," "AUTO CHEMIC," "CHAMFER-TRODE," "COPWELD," "SIL WELD," "LOW AMP," "LOW TEMP," "UNIMATIC," "XYRON," "NITECTIC"
Flood City Brass & Electric Co.
Guyan Machy. Co.—"MUREX"
Harnischfeger Corp.
Hobart Bros. Co.
Lincoln Electric Co.—"JET-WELD," "FLEETWELD," "SHIELD-ARC," 'STAIN-WELD," "ALUMINUM-WELD, "AERISWELD," "FERRO-WELD," "PLANE-WELD"
Marathon Coal Bit Co. Inc.—"AIRCO"
Metal & Thermit Corp.—"MUREX"
Mosebach Electric & Supply Co.
Stulz-Sickles Co.—"MAN-GANAL"
Taylor-Wharton Co. Div., Harsco Corp.—"TIMANG"
Wall Colmonoy Corp.—"HARD-FACING"
Westinghouse Electric Corp.

WELDING ELECTRODES, NICKEL, NICKEL ALLOY

International Nickel Co., Inc.

WELDING ELECTRODES, CARBON

Crucible Steel Co. of America—"STAINLESS"
Helwig Co.
Hobart Bros. Co.
Lincoln Electric Co.—"E 321" "E882"
Marathon Coal Bit Co. Inc.—"AIRCO"
National Carbon Co., Div. of Union Carbide Corp.
Ohio Carbon Co.
Pure Carbon Co., Inc.
Stackpole Carbon Co.

WELDING ELECTRODES, GRAPHITE

Helwig Co.

Hobart Bros. Co.
Marathon Coal Bit Co. Inc.—"AIRCO"
National Carbon Co., Div. of Union Carbide Corp.
Ohio Carbon Co.
Stackpole Carbon Co.

WELDING EQUIPMENT, INERT GAS ARC

Air Reduction Sales Co., A Div. of Air Reduction Co., Inc.

WELDING FITTINGS & FLANGES

L. B. Foster Co.

WELDING-FLUX RECLAMING SCREENS

Simplicity Engineering Co.

WELDING FLUXES

Eutectic Welding Alloys Corp.—"EUTECTOR FLUXES"
Lincoln Electric Co.—"760," "780," "781," "840"
Marathon Coal Bit Co. Inc.—"AIRCO"
The Sight Feed Generator Co.—"REXARC"
Victor Equipment Co.

WELDING GASES

Air Reduction Sales Co., A Div. of Air Reduction Co., Inc.
Guyan Machy. Co.
Marathon Coal Bit Co. Inc.—"AIRCO"

WELDING GOGGLES

Air Reduction Sales Co., A Div. of Air Reduction Co., Inc.
American Optical Co., Safety Products Div.—"NOVI-WELD," "DURAWELD"
Bausch & Lomb Optical Co.
E. D. Bullard Co.
Chicago Eye Shield Co.
Flood City Brass & Electric Co.
General Scientific Equipment Co.—"GS"
Guyan Machy. Co.
Hobart Bros. Co.
Marathon Coal Bit Co. Inc.—"AIRCO"
Mine Safety Appliance Co.
Ore Reclamation Co.
Pulmosan Safety Equip. Co.
United States Safety Service Co.

WELDING GROUND CLAMPS

Albert & J. M. Anderson Mfg. Co.
Erico Products, Inc.—"CADDY"
Flood City Brass & Electric Co.
Hobart Bros. Co.
Lincoln Electric Co.—"GC 300," "GC 500"
Marathon Coal Bit Co., Inc.—"AIRCO"
Ohio Brass Co. "KLIPLOK"
Trico Fuse Mfg. Co.
Tweco Products, Inc.—"TWECO"

WELDING HELMETS

American Optical Co., Safety Products Div.—"WELD COOL"
E. D. Bullard Co.
Chicago Eye Shield Co.
Flood City Brass & Electric Co.
General Scientific Equipment Co.—"GS"
Guyan Machy. Co.
Hobart Bros. Co.
Lincoln Electric Co.—"COMFORT SHIELD," "LPH," "FMH"
Marathon Coal Bit Co. Inc.—"AIRCO"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.
Westinghouse Electric Corp.

WELDING HOLDERS

Flood City Brass & Electric Co.
Hobart Bros. Co.
The Wood Shovel & Tool Co.
Marathon Coal Bit Co. Inc.—"AIRCO"

WELDING HOSE

Carlyle Rubber Co., Inc.
Goodyear Tire & Rubber Co.
Guyan Machy. Co.
Hamilton Rubber Mfg. Corp.—"STAPLE"
Hewitt-Robbins Incorporated—"TWIN-WELD"
Industrial Rubber Products Co. (Pa.)
Marathon Coal Bit Co. Inc.—"AIRCO"
Raybestos Manhattan, Inc., Manhattan Rubber Div.
Thermoid Co.

WELDING LUGS

Tweco Products, Inc.

WELDING PLUGS, ELECTRICAL

Joy Mfg. Co.

WELDING POSITIONERS

Harnischfeger Corp.
The Sight Feed Generator Co.—"REXARC"

WELDING RECTIFIERS

General Nuclear Corp.
Hobart Bros. Co.
Marathon Coal Bit Co. Inc.—"AIRCO"

WELDING ROD, WIRE

American Brake Shoe Co., Amsco Div.—"AMSCO"

WELDING SHIELDS

American Optical Co., Safety Products Div.
Flood City Brass & Electric Co.
General Scientific Equipment Co.—"GS"
Hobart Bros. Co.
Marathon Coal Bit Co. Inc.—"AIRCO"
Mine Safety Appliances Co.
Pulmosan Safety Equip. Co.
Westinghouse Electric Corp.

WELDING TRANSFORMERS

Guyan Machy. Co.—"M & T"
Hobart Bros. Co.
Lincoln Electric Co.—"IDEALARC," "FLEETWELDER"
Marathon Coal Bit Co. Inc.—"AIRCO"
Westinghouse Electric Co.

WELDING-TUBE FITTINGS

Parker Fittings & Hose Div., Parker-Hannifin Corp.—"WELD-LOK"

WELDING WIRE

Drawalloy Corp.—"DRAW-ALLOY"
Stoody Co.—"STOODY"

WELDING WIRE, AUTOMATIC

The Sight Feed Generator Co.—"REXARC"

WELDMENTS

American Brake Shoe Co., Amsco Div.—"AMSCO"
American Car & Foundry Div., ACF Industries, Inc.
Bethlehem Steel Co.
Connellsville Mfg. & Mine Supply Co.
Falk Corp.
Farrel-Birmingham Co., Inc.
L. O. Koven & Bro., Inc.
Meckum Engr. Co.
Phoenix Iron & Steel Co., Structural & Tube Divs.
Sanford Day Iron Works, Inc.

WELDMENTS, CAST

Electric Steel Foundry Co.

WETTING AGENTS

American Cyanamid Co., Explosives and Mining Chemicals Dept.—"AEROSOL"
American Minechem Co.

WHEELBARROWS

The Wood Shovel & Tool Co.

WHEELBARROWS, POWERED

Prime Mover Co.—"15A"

WHEELS, LOCOMOTIVE, CAST-IRON

American Car & Foundry Div., ACF Industries, Inc.
Ironton Engine Co.—"IRONTON"
Irwin Foundry & Mine Car Co.

WHEELS, LOCOMOTIVE, STEEL

Bethlehem Steel Co.
Ironton Engine Co.—"IRONTON"
Pittsburgh Gear Co.
Sterling Steel Casting Co.

WHEELS, LOCOMOTIVE, STEEL REBUILT

Leman Machine Co.

WHEELS, MACHINE-TRUCK

Enterprise Wheel & Car Corp.
Irwin Foundry & Mine Car Co.
United States Rubber Co.

WHEELS, MINE-CAR

Bi-Metal Products Co., Div. of American Alloy Corp.—"BI-METAL"
Link-Belt Co., Dept. CAMGL-58

WHEELS, MINE-CAR, CAST-IRON

American Car & Foundry Div., ACF Industries, Inc.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Gibralter Equipment & Mfg. Co.
Helmick Foundry-Machine Co.
Hockensmith Corp.
Irwin Foundry & Mine Car Co.
Kanawha Mfg. Co.
McLanahan & Stone Corp.
Sanford Day Iron Works, Inc.
Watt Car & Wheel Co.

WHEELS, MINE-CAR, MANGANESE

Kensington Steel, Div. of Poor & Co.

WHEELS, MINE-CAR, REBUILT

Bi-Metal Products Co., Div. of American Alloy Corp.

WHEELS, MINE-CAR, STEEL

American Brake Shoe Co., Amsco Div.—"AMSCO"
Bethlehem Steel Co.
C. S. Card Iron Works
Enterprise Wheel & Car Corp.
Gibralter Equipment & Mfg. Co.
Irwin Foundry & Mine Car Co.
National Malleable & Steel Castings Co.—"NACO"
Sanford Day Iron Works, Inc.
Sterling Steel Casting Co.
Watt Car & Wheel Co.

WINCHES

Chicago Pneumatic Tool Co.
J. D. Christian Engineers
Clyde Iron Works, Inc.
Cowanesque Valley Iron Works
Gar Wood Industries, Inc.
Ledeen Mfg. Co.
Link-Belt Co., Dept. CAMGL-58
Sauerman Bros., Inc.
Shepard Niles Crane & Hoist Corp.
Stephens-Adamson Mfg. Co.
Vickers, Inc., Tulsa Winch Div.—"TULSA"

WINCHES, AIR

Joy Mfg. Co.

WINCHES, PIPE DRIVING

Sprague & Henwood, Inc.

WINDOWS, INDUSTRIAL STEEL

Steelcraft Mfg. Co.

WIRE

Republic Steel—"REPUBLIC"

WIRE, ARMATURE BENDING, STAINLESS, CARBON STEEL

Page Steel & Wire Div., American Chain & Cable Co., Inc.

WIRE, ELECTRICAL—See Also Cable

WIRE, ELECTRICAL, BARE

American Steel & Wire Div., U. S. Steel Corp.—"TIGER BRAND"
Circle Wire & Cable Corp.
Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"
John Flocker & Co.
General Cable Corp.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
Rome Cable Corp.

WIRE, ELECTRICAL, INSULATED

American Steel & Wire Div., U. S. Steel Corp.
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"
Cornish Wire Co., Inc.
Ensign Electric & Mfg. Co.
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.
Joy Mfg. Co.
Kaiser Aluminum & Chemical Sales, Inc.
National Electric Products Co.
National Mine Service Co.
Okonite Co.
Phelps Dodge Copper Products Co.
Reynolds Metals Co.
Rockbestos Products Corp.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
Rome Cable Corp.
Simplex Wire & Cable Co.

WIRE, FEEDER

Aluminum Company of America
American Steel & Wire Div., U. S. Steel Corp.
Anaconda Wire & Cable Co.
Circle Wire & Cable Corp.
Collyer Insulated Wire Co.
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.
Joy Mfg. Co.
Kaiser Aluminum & Chemical Sales, Inc.
Mosebach Electric & Supply Co.
Phelps Dodge Copper Products Co.
Rome Cable Corp.

WIRE, SHAPED

Page Steel & Wire Div., American Chain & Cable Co., Inc.

WIRE, SHOTFIRING

American Steel & Wire Div., U. S. Steel Corp.
Circle Wire & Cable Corp.
Cornish Wire Co., Inc.
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.
Kaiser Aluminum & Chemical Sales, Inc.
King Powder Co., Inc.
National Mine Service Co.
Okonite Co.
Olin-Mathieson Chemical Corp., Explosives Div.
Rome Cable Corp.

WIRE, TELEPHONE

American Steel & Wire Div., U. S. Steel Corp.
Copperweld Steel Co., Wire & Cable Div.—"COPPERWELD"
John Flocker & Co.
General Cable Corp.
General Electric Co., Construction Materials Div.

Kaiser Aluminum & Chemical Sales, Inc.
Page Steel & Wire Div., American Chain & Cable Co., Inc.—"ACCOALUMINIZED"
National Electric Products Co.
Okonite Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.

WIRE, THERMOCOUPLE

West Instrument Corp.

WIRE, TROLLEY

Aluminum Co. of America.
American Steel & Wire Div., U. S. Steel Corp.
Anaconda Wire & Cable Co.
John Flocker & Co.
General Cable Corp.
Mosebach Electric & Supply Co.
National Mine Service Co.
Phelps Dodge Copper Products Co.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.

WIRE CLOTH

Hewitt-Robins Incorporated—"GYRALOY," "SUPER GYRALOY"
Hoyt Wire Cloth Co.—"SUPERTOUGH," "ABRASO," "STAINLESS STEEL," "SMOOTH TOP," "LONGSLOT," "OBLONG," "DOUBLE CRIMP"
Ludlow Saylor Wire Cloth Co.
W. S. Tyler Co.

WIRE CLOTH, STEEL

Cleveland Wire Cloth & Mfg. Co

WIRE ENAMELS

General Electric Co., Chemical & Metallurgical Div., Insulating Materials Section

WIRE ROPE

American Chain & Cable—"LAY-SET," "TRU-LAY," "VHS"
American Steel & Wire Div. U. S. Steel Corp.
Bergen Wire Rope Co.
Bethlehem Steel Co.
The Bowdil Co.
Broderick & Bascom Rope Co.—"YELLOW STRAND," "POWERSTEEL"
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M. Glosser & Sons Inc.
Guyan Machy. Co.
Jones & Laughlin Steel Corp.
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Rochester Ropes, Inc.
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Joseph T. Ryerson & Son, Inc.
Sauerman Bros., Inc.
W. J. Savage Co.
Union Wire Rope Corp. Sub of Armco Steel Corp.—"TUFFY"
Upson-Walton Co.
West Virginia Armature Co.
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WIRE ROPE, PLASTIC COATED

Rochester Ropes, Inc.

WIRE ROPE, SWING TAIL, CAR-PULLER

Upson-Walton Co.

WIRE, ROPE, STAINLESS, MONEL, PLASTIC COATED AND NYLON COATED

Macwhyte Wire Rope Co.

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John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
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W. J. Savage Co.
Union Wire Rope Corp., Div. of Armco Steel Corp.
Upson-Walton Co.—"GOLD CLIP"
Wire Rope Corp. of America, Inc.—"WIRECO"

WIRE-ROPE DRESSING, LUBRICANTS

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Cities Service Oil Co.
Esso Standard Oil Co.—"SURETT," "SURETT FLUIDS," "COBLAX"
John Flocker & Co.
Hulbert Oil & Grease Co.
Jones & Laughlin Steel Corp.
Leschen Wire Rope Div., H. K. Porter Co. Inc.—"LEPRO"
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New York & New Jersey Lubricant Co.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
Shell Oil Co.
Socony Mobil Oil Co. Inc.
Sun Oil Co. "AEROSOL"
Swan-Finch Petro Chemicals
The Texas Co.

WIRE-ROPE, CONDUCTOR-CORE

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WIRE-ROPE EYES

American Chain & Cable
Crosby Laughlin Div., American Hoist & Derrick Co.
John Flocker & Co.
Jones & Laughlin Steel Corp.
Joy Mfg. Co.
Leschen Wire Rope Div., H. K. Porter Co. Inc.
Macwhyte Wire Rope Co.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
Union Wire Rope Corp. Div. of Armco Steel Corp.

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American Chain & Cable
Crosby Laughlin Div., American Hoist & Derrick Co.—"CROSBY," "LAUGHLIN"
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John Flocker & Co.
Jones & Laughlin Steel Corp.
Leschen Wire Rope Div., H. K. Porter Co., Inc.
Macwhyte Wire Rope Co.
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Union Wire Rope Corp., Div. of Armco Steel Corp.
Upson-Walton Co.

WIRE-ROPE SLINGS

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Leschen Wire Rope Div., H. K. Porter Co., Inc.
John A. Roebling's Sons Corp. Sub., Colorado Fuel & Iron Corp.
Union Wire Rope Corp., Div. of Armco Steel Corp.
Upson-Walton Co.
Wire Rope Corp. of America, —"WIRECO"

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Union Wire Rope Corp., Div. of Armco Steel Corp.
Wire Rope Corp. of America, Inc. "WIRECO"

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Black & Decker Mfg. Co.
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WRENCHES, SET SCREW

The Leetonia Tool Co.

WRENCHES, TORQUE

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The Nolan Co.

YO-YOS, HYDRAULIC

The Nolan Co.
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Acker Drill Co., Inc., P. O. Box 830, Scranton, Pa.

Acme Chain Corp., 821 Main St., Holyoke, Mass.

Acme Machinery Co., Box 1169, Williamson, West Va.

Advance Car Mover Co., Inc., Box 536, Appleton, Wis.

Aerial Surveys, Inc., 4614 Prospect Ave., Cleveland, Ohio

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Allis-Chalmers Mfg. Co., Industrial Equipment Div., 968 South 70 St., Milwaukee 1, Wis.

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American Brattice Cloth Corp., Warsaw, Inc.

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American Cyanamid Co., Explosives and Mining Chemicals Dept., 30 Rockefeller Plaza, New York 20, N. Y.

American Engineering Co., Wheatsheaf Lane & Sepviva St., Philadelphia 37, Pa.

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American LaFrance Corp., 160 East LaFrance St., Elmira, N. Y.

American Logging Tool Corp., Sub. of Broderick & Bascom Rope Co., 4203 Union Blvd., St. Louis 15, Mo.

American MARC Inc., 1601 West Florence Ave., P. O. Box 549, Inglewood, Calif.

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Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.

Analytical Measurements, Inc., 585 Main St., Chatham, N. J.

Anchor Coupling Co., Inc., 342 N. Fourth St., Libertyville, Ill.

Anchor Packing Co., 401 North Broad St., Philadelphia 8, Pa.

Albert & J. M. Anderson Mfg. Co., 289 A St., Boston 10, Mass.

The Ansonia Wire & Cable Co., 111 Martin St., Ashton, R. I.

Ansul Chemical Co., Marinette, Wis.

Armco Drainage & Metal Prod., Inc., Middletown, Ohio

Armstrong-Bray & Co., 5364 Northwest Hwy., Chicago 30, Ill.

Arrow Hart & Hegeman Electric Co., 104 Hawthorne St., Hartford 6, Conn.

Arrowhead Constructors and Engineers, Inc., 1122 W. Railroad St., Duluth, Minn.

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Barber-Greene Co., 400 N. Highland Ave., Aurora, Ill.

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Barnes Mfg. Co., 615 N. Main St., Mansfield, Ohio

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Bemis Bro. Bag Co., 408-0 Pine St., St. Louis 2, Mo.
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Bethlehem Steel Co., 701 East Third St., Bethlehem, Pa.
B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I.
Bigelow-Liptak Corp., 13300 Puritan Ave., Detroit 27, Mich.
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The Brooks Oil Co., 3304 East 87th St., Cleveland 27, Ohio
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C & D Batteries, Inc., Conshohocken, Pa.
Cable Vulcanizing Shop, Inc., Box 66, Pecks Mill, W. Va.
Samuel Cabot, Inc., 141 Milk St., Boston 9, Mass.
Cambridge Wire Cloth, Cambridge, Md.
E. K. Campbell Co., 1809 Manchester Ave., Kansas City 26, Mo.
Canton Stoker Corp., 741 Andrew Place, S. W. Canton, Ohio
C. S. Card Iron Works, P. O. Box 17, Denver 1, Colo.
Cardox Corp., 307 North Michigan Ave., Chicago 1, Ill.
Philip Carey Mfg. Co., Lockland, Cincinnati 15, Ohio
Carlon Products Corp., 10225 Meech Ave., Cleveland 5, Ohio
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Carolina Tire Co., 232 N. Main St., Salisbury, N. C.
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A. W. Cash Co., P. O. Box 551, Decatur, Ill.
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J. D. Christian Engineers, 480 Potrero Ave., San Francisco 10, Calif.
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Circle Wire & Cable Corp., 5500 Maspeth ve., Maspeth, Long Island, N. Y.
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Cleveland Vibrator Co., 2828 Clinton Ave., Cleveland, Ohio
Cleveland Wire Cloth & Mfg. Co., 3573 E. 78th St., Cleveland 5, Ohio
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Coast Metals, Inc., Redneck Ave., Little Ferry, N. J.
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Continental Gin Co., Ind. Div., 4505—5th Ave. So., Birmingham, Ala.
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D-A Lubricant Co., Inc., 1331 West 29 St., Indianapolis 23, Ind.
Dallas Engineers, Inc., Coal-O-Matic Div., Main St., Trucksville, Pa.
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The Dayton Rubber Co., Dayton 1, Ohio
Dean Brothers Pumps Inc., 323 West Tenth St., Indianapolis 7, Ind.
The Deister Concentrator Co., 901 Glasgow Ave., Ft. Wayne 1, Ind.
Deister Machine Co., 1933 E. Wayne St., Ft. Wayne 4, Ind.
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Herb J. Hawthorne, Inc., Box 7366, Houston 8, Tex.
Ideal-Simplet Fittings, Inc., 1020 Park Ave., Sycamore, Ill.
ington 14, W. Va.; Box 1152, Kingston, Pa.; 1203 Mackilad
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Denver Equipment Co., P. O. Box 5268, Denver 17, Colo., ADV. p 261
Detroit Diesel Engine Div., General Motors Corp., 13400 West Outer Drive, Detroit 28, Mich.
Detroit Controls Div., American Radiator & Standard Sanitary Corp., D. T. Williams Valves, P. O. Box 741, Bridgeport 1, Conn.
Diamond Chain Co., Inc., 402 Kentucky Ave., Indianapolis 7, Ind.
Diamond Crystal Salt Co., St. Clair, Mich.
Diamond Iron Works, Div. Goodman Mfg. Co., Halsted St. & 48th Pl., Chicago 9, Ill.
Diamond Power Specialty Corp., Electronics Div., Lancaster, Ohio
Diamond Tool Research Co., Inc., 380 Second Ave., New York 10, N. Y.
Diehl Mfg. Co., 1208 Finderne Ave., Somerville, N. J.
Diesel Energy Corp., 82 Beaver St., New York, N. Y.
Differential Steel Car Co., Differential Ave., Findlay, Ohio
Dings Magnetic Separator Co. 4724 W. Electric Ave., Milwaukee 46, Wis.
Disston Div., H. K. Porter Co., Inc., Philadelphia 35, Pa.
Joseph Dixon Crucible Co., Monmouth & Wayne Sts., Jersey City 3, N. J.
Dodge Div., Chrysler Corp., 7900 Jos. Campau, Detroit 31, Mich.
Dodge Mfg. Corp., South Union St., Mishawaka, Ind.
Dooley Brothers, 1201 S. Washington St., Peoria, Ill.
Dorr-Oliver, Inc., Stamford, Conn.
The Dow Chemical Co., Midland, Mich.
Dow Corning Corp., Midland, Mich.
Dravo Corp., Neville Island, Pittsburgh 25, Pa., ADV. p 246
Drawalloy Corp., Lincoln Highway West at Alloy St., York, Pa.
Dresser Mfg. Div., Dresser Industries, Inc., Bradford, Pa.
The Ducon Co., Inc., 154 E. Second St., Mineola, N. Y.
Duff-Norton Co., 2709 Preble Ave., Pittsburgh, 30, Pa., ADV. p 251
E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del.
E. I. du Pont de Nemours & Co., Inc., Explosives Div., 2543 Nemours Bldg., Wilmington 98, Del.
Duquesne Mine Supply Co., Pittsburgh 9, Pa.
Durakool, Inc., 1010 North Main St., Elkhart, Ind.
The Duriron Co., Inc., 450 North Findlay St, Dayton 4, Ohio
Dynamatic Div., Eaton Mfg. Co., 3307-14th Ave., Kenosha, Wis.

E

Eagle Iron Works, 61 Holcomb Ave., Des Moines 4, Iowa
Eaton Mfg. Co., Axle Div., 739 East 140th St., Cleveland 10, Ohio
Eavenson, Auchmuty & Greenwald, 2720 Koppers Bldg., Pittsburgh 19, Pa.
Economy Fuse & Mfg. Co., 2717 N. Greenview Ave., Chicago 14, Ill.
Thomas A. Edison Industries, McGraw-Edison Co., Storage Battery Div., West Orange, N. J.
Eimco Corp., 630 South 4th West St., Salt Lake City 10, Utah
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.
Electric Machinery Mfg. Co., 800 Central Ave., Minneapolis 13, Minn.
The Electric Products Co., 1725 Clarkstone Rd., Cleveland 12, Ohio
Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland 10, Oregon
Electrical Distributors Co., Penn Square Building, Philadelphia 7, Pa.
Electro-Alloys Div., American Brake Shoe Co., Taylor St. & Abbe Rd., Elyria, Ohio
Electro Dynamics Div. of General Dynamics Corp., 163 Avenue A, Bayonne, N. J.
Elliott Co., 900 N. Fourth Ave., Jeannette, Pa.
Elliott Service Co., Inc., 30 N. MacQuesten Pkwy., Mt. Vernon, N. Y.
The Elreco Corp., 2900 Cormany Ave., Cincinnati 25, Ohio
Emgio Products Corp., 116 Dupont St., Johnstown, Pa.
Ensign-Bickford Co., Simsbury, Conn.
Ensign Electric & Mfg. Co., 914 Adams Ave., Huntington, W. Va.
Enterprise Wheel & Car Corp., Bristol, Va., and Huntington, W. Va., ADV. p 267
Erico Products, Inc., 2070 E. 61 Pl., Cleveland 3, Ohio
Eriez Manufacturing Co., 259 Magnet Drive, Erie, Pa.
Esso Standard Oil Co., 15 West 51 St., New York, N.Y.
Eutectic Welding Alloys Corp., 40-40 172 St., Flushing 58, N. Y.
Exide Industrial Div., Electric Storage Battery Co., 42 South 15th St., Philadelphia 2, Pa. ADV. p 247
Extremultus, Inc., 405 Lexington Ave., New York 17, N. Y.

F

The Fafnir Bearing Co., 37 Booth St., New Britain, Conn.
George E. Failing Co., Sub. of Westinghouse Air Brake Co., Enid, Okla.
The Fairbanks Co., 393 Lafayette St., New York 3, N. Y.
Fairchild Aerial Surveys, Inc., 224 E. 11th St., Los Angeles 15, Calif.
Fairmont Machinery Co., Fairmont, W. Va. ADV. p 193
Fairview Bit Co., Fairview, W. Va.
Falk Corp., 3057 W. Canal St., Milwaukee 1, Wis., ADV. p 201
Farrel-Birmingham Co., Inc., 25 Main St., Ansonia, Conn.
Farris Flexible Valve Corp., 400 Commercial Ave., Palisades Park, N. J.
Farval Corp., 3300 East 80th St., Cleveland 4, Ohio
The Federal Bearings Co., Inc., Poughkeepsie, N. Y.
Femco, Inc., Irwin, Pa. ADV. p. 207
Fetterman Engineering Co., 1004 Jtwn. Bank & Trust Bldg., Johnstown, Pa.
Filter Fabrics, Inc., 814 E. Jefferson St., Goshen, Ind.
Firth Sterling, Inc., 3113 Forbes St., Pittsburgh 30, Pa.
Fischer & Porter Co., 505 Warminster Rd., Hatboro, Pa.
Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.
J. H. Fletcher & Co., Box 2143, Huntington 18, W. Va.
Flexaust Co., 100 Park Ave., New York 17, N. Y.
Flexible Steel Lacing Co., 4607 Lexington St., Chicago 44, Ill.
John Flocker & Co., 644 Grant St., Pittsburgh 19, Pa.
Flood City Brass & Electric Co., Messenger & Elder Sts., Johnstown, Pa. ADV. p 242
Fluor Products Co., A Div. of The Fluor Corp. Ltd., 12000 E. Washington Blvd., Whittier, Calif.
Fly Ash Arrestor Corp., 280 First St. N., Birmingham, Ala.
Foote Brothers Gear & Machinery Corp., 4545 South Western Blvd., Chicago, Ill.
Ford Div. of Ford Motor Co., P. O. Box 658, Dearborn, Mich.
L. B. Foster Co., P. O. Box 1647, Pittsburgh 30, Pa.
Foster Wheeler Corp., 666 Fifth Ave., New York 19, N. Y.
The Four Wheel Drive Auto Co., Clintonville, Wis.
Foxboro Co., Foxboro, Mass.
Franklin Plastics Inc., 315 Grant St., Franklin, Pa.
Fred's Welding Service, P. O. Box 178 Grundy, Va., ADV. p 275
The Frick-Gallagher Mfg. Co., 201 S. Michigan Ave., Wellston, Ohio
Fuel Process Co., 900 D St., South Charleston, W. Va., ADV. p 285
Fuller Mfg. Co., 1419 North Burdick St., Kalamazoo, Mich.
Fulton Bag & Cotton Mills, P. O. Box 1726, Atlanta 1, Ga.
Fyr-Fyter Div., 221 Crane St., Dayton 1, Ohio

G

G & W Electric Specialty Co., 3500 W. 127 St., Blue Island, Ill.
Galigher Co., 545 West 8th South, P. O. Box 209, Salt Lake City 10, Utah
Galion Allsteel Body Co., Galion, Ohio
Galion Iron Works & Mfg. Co., Galion, Ohio
Gar Wood Industries, Inc., Wayne, Mich.
Gardner - Denver Company, Quincy, Ill.
The Garlock Packing Co., 402 East Main St., Palmyra, N. Y.
The Gates Rubber Co. Sales Div., Inc., 999 South Broadway, Denver 17, Colo.
General Cable Corp., 420 Lexington Ave., New York 17, N. Y.
General Electric Co., Apparatus Sales Div., 1 River Road, Schenectady 5, N. Y.
General Electric Co., Chemical and Metallurgical Div. Insulating Materials Section, 1 River Rd., Bldg. 23, Schenectady, N. Y.
General Electric Co., Communication Products Dept., Electronics Park, Syracuse, N. Y.
General Electric Co., Construction Materials Div., Bridgeport 2, Conn.
General Electric Co., Lamp Div., Nela Park, Cleveland 12, Ohio
General Electric Co., Locomotive & Car Equipment Dept., 2901 E. Lake Rd., Erie 1, Pa.
General Logistics, 990 S. Fair Oaks Ave., Pasadena, Calif.
General Motors Corp., Euclid Division, 1361 Chardon Road, Cleveland 17, Ohio
General Nuclear Corp., 550 Fifth Ave., New York 14, N. Y.
General Scientific Equipment Co., 7516 Limekiln Pike, Philadelphia 50, Pa.
General Splice Corp., 85 Spring St., South Norwalk, Conn.
Gensco Tools Div., General Steel Warehouse Co., Inc., 1830 N. Kostner Ave., Chicago 39, Ill.
Geo-Optic Co., Inc., 149 Church St., New York 7, N. Y.
Gering Products, Inc., North Seventh St. and Monroe Ave., Kenilworth, N. J.
Gibraltar Equipment & Mfg. Co., P. O. Box 304, Alton, Ill.
M. Glosser & Sons Inc., 80 Messenger St., Johnstown, Pa.
Goodall Rubber Co., Whitehead Rd., Trenton, N. J.
Goodman Mfg. Co., Halsted St. & 48th Place, Chicago 9, Ill.
B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio
B. F. Goodrich Industrial Products Co., 500 South Main St., Akron 18, Ohio
B. F. Goodrich Tire Co., A Div. of the B. F. Goodrich Co., Akron, Ohio
Good Year Tire & Rubber Co., 1144 East Market St., Akron 16, Ohio
Gorman-Rupp Co., Mansfield, Ohio
Gould-National Batteries, Inc., Trenton 7, N. J.
Goulds Pumps, Inc., Seneca Falls, N. Y.
Goyne Pump Co., Ashland, Pa.
Gray & Co., Inc., 56 Eleventh Ave., N. E., Minneapolis 13, Minn.
Graybar Elec. Co., Inc., 420 Lexington Ave., New York 17, N. Y.
Grinnell Co., 260 West Exchange St., Providence 1, R.I.
Gruendler Crusher & Pulverizer Co., 2917 No. Market St., St. Louis 6, Mo.
Gulf Oil Corp., P. O. Box 1166, Pittsburgh 30, Pa.
T. J. Gundlach Machine Co., Div. J. M.J. Industries, Inc., P. O. Box 283, Belleville, Ill., ADV. p 221
Gurley, W. & L. E., 514 Fulton St., Troy, N. Y.
Gustin-Bacon Mfg. Co., 210 West Tenth St., Kansas City, Mo.
Guyan Machy. Co., 755 Stratton, Logan, W. Va.

H

H & L Tooth Co., 1540 South Greenwood Ave., Montebello Calif., ADV. p 215
Hackbridge & Hewittic Electric Co., Ltd., P. O. Box 234, Pittsburgh 30, Pa.
George Haiss Mfg. Co. Div., Pettibone Mulliken Corp., 350 Fifth Ave., New York, N. Y.
Hamilton Rubber Mfg. Corp., Meade St., Trenton, N. J.
J. V. Hammond Co., Spangler, Pa.
F. R. Hannon & Sons, Canton 7, Ohio
Hardinge Co., Inc., 240 Arch St., York, Pa.
Harnischfeger Corp., 4400 W. National Ave., Milwaukee 46, Wis., ADV. p 7
The Harrington & King Perforating Co., Inc., 5655 W. Fillmore St., Chicago 44, Ill.
Hauck Mfg. Co., 144-154 Tenth St., Brooklyn 15, N. Y.
The Hauser-Stander Tank Co., 4838 Spring Grove Ave., Cincinnati 32, Ohio, ADV. p 242

Herb J. Hawthorne, Inc., Box 7366, Houston 8, Tex.
Hays Corp., 742 E. 8th St., Michigan City, Ind.
Heintz Mfg. Co., 13110 Enterprise Ave., Cleveland, Ohio
Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.
Helmick Foundry-Machine Co., P. O. Box 71, Fairmont, W. Va.
Helwig Co., 2500 N. 30th St., Milwaukee 10, Wis.
Hendrick Mfg. Co., Carbondale, Pa., ADV. p 239
Henrickson Mfg. Co., 8001 W. 47th St., Lyons, Ill.
Hendrix Mfg. Co., P. O. Box 31, Mansfield, La.
Hercules Motors Corp., 101 11 St., S. E., Canton, Ohio
Hercules Powder Co., Delaware Trust Bldg., 900 Market St., Wilmington, Del., ADV. p 241
Hercules Steel Products Co., Galion, Ohio
Herold Mfg. Co., 215 Hickory St., Scranton 5, Pa.
Hevi-Duty Electric Co., 2040 W. Wisconsin Ave., Milwaukee 1, Wis.
Hewitt-Robins, Incorporated 666 Glenbrook Rd., Stamford, Conn., ADV. p 265
Heyl & Patterson, Inc., 55 Fort Pitt Blvd., Pittsburgh 22, Pa. ADV. p 11
Hobart Bros. Co., Hobart Square, Troy 1, Ohio
Hockensmith Corp., Penn, Pa.
Hodag Chemical Corp., 7247 North Central Park, Chicago 45, Ill.
Hoffman Bros. Drilling Co., Tiona and Ceder Sts., Punxsutawney, Pa.
Hoffman Combustion Engrg. Co., 1780 Southfield Rd., Lincoln Park, Mich.
Robert Holmes & Bros., Inc., 510 Junction Ave., Danville, Ill.
Holu Industries, Inc., 416 DeKalb Ave., Sycamore, Ill.
Homelite, Div. of Trextron Inc., 75 Riverdale Ave., Port Chester, N. Y.
The Homer Mfg. Div., The Ohio Electric Mfg. Co., Pearl St., Lima, Ohio.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Hose Accessories Co., 17th St. & Lehigh Ave., Philadelphia 32, Pa.
Hossfeld Mfg. Co., 460-462 W. Third St., Winona, Minn.
The Frank G. Hough Co., 735 Seventh St., Libertyville, Ill.
Howe Scale Co., Rutland, Vt.
Howells Mining Drill Co., Plymouth, Pa.
Hoyt Wire Cloth Co., P. O. Box 1577, Lancaster, Pa.,
Huber-Warco Co., Marion, Ohio ADV. p 233
Hughes Tool Co., 300 Hughes St., Houston, Tex.
Hulburt Oil & Grease Co., Trenton & Castor Ave., Philadelphia 34, Pa.
C. B. Hunt & Son, Inc., Salem, Ohio
Hyatt Bearings Div., General Motors Corp., Harrison, N. J.
Hyster Co., 2903-39 N.E. Clackamas St., Portland 8, Ore.
Hy-Test Safety Shoe Div., International Shoe Co., 1509 Washington Ave., St Louis 13, Mo.

I

I-T-E Circuit Breaker Co., 19 & Hamilton Sts., Philadelphia 30, Pa.
Ideal Industries, Inc., 1020 Park Ave., Sycamore, Ill.
Ideal-Simplet Fittings, Inc., 1020 Park Ave., Sycamore, Ill.
Ilg Electric Ventilating Co., 2850 N. Pulaski Rd., Chicago 41, Ill.
Illinois Zinc Co., 2959 W. 47th St., Chicago 32, Ill.
Imperial-Cantrell Mfg. Co., P.O. Box 538, Jellico, Tenn.
Industrial Engrg. & Construction Co., Inc., First National Bank Bldg., Fairmont, W. Va.
Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio
Industrial Physics & Electronics Co., 470 So. 10th East, Salt Lake City, Utah
Industrial Rubber Products Co., 505 Magee St., Pittsburgh 19, Pa.
Industrial Rubber Products Co., 815 Court St., Charleston, W. Va.
Industrial Sales Dept., John Bean Div., Food Machinery & Chemical Corp., Box 840, Lansing, Mich.
Infilco Inc., P. O. Box 5033, Tucson, Ariz.
Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y., ADV. p 9
Inland Steel Co., 30 W. Monroe St., Chicago 3, Ill.
Insley Mfg. Corp., 801 Olney St., Indianapolis 1, Ind.; Gen. Offices—Indianapolis, Ind.; West Coast Div.—Los Angeles, Calif.
Instrument Div., Gichner, Inc., 1900 Kendall St., N.E., Washington 2, D. C.
International Harvester Co., Construction Equipment Div., North Ave. and Manheim Rd., Melrose Park, Ill.
International Harvester Co., Motor Truck Div., 180 N. Michigan Ave., Chicago 1, Ill.
International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
International Salt Co., Inc., Scranton 2, Pa.
Interstate Equipment Corp., 433 N. Broad St., Elizabeth 3, N. J.
Iowa Mfg. Co., 916 16 St., N.E., Cedar Rapids, Iowa
Ironton Engine Co., Farmingdale, N. J.
Irwin Foundry & Mine Car Co., Box 311, Irwin, Pa.
Irvington Div. of Minnesota Mining & Mfg. Co., St. Paul, Minn.

J

Jeffrey Mfg. Co., 922 N. Fourth St., Columbus 16, Ohio
Jenkins Bros., 100 Park Ave., New York 17, N. Y.
Johns-Manville, 22 East 40 St., New York 16, N. Y.
Johnson Bronze Co., 492 S. Mill St., New Castle, Pa.
Johnson-March Corp., 1724 Chestnut St., Philadelphia 3, Pa.
Johnson Plastic Corp., P. O. Box 100, Chagrin Falls, Ohio
G. R. Johnson Loading Supplies 5026 Butterworth Rd., Mercer Island, Wash.
The R. G. Johnson Co., 25 S. College St., Washington, Pa.
Johnston Pump Co., Div. of The Youngstown Sheet and Tube Co., P. O. Bin K, Pasadena, Calif.
Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.
Joy Mfg. Co., 333 Oliver Bldg., Pittsburgh 22, Pa.; Coal Machy. Div., 4107 Senott St., Pittsburgh 13, Pa.; 742 Eighth Ave., P. O. Box 1208, Huntington 14, W. Va.; Box 1152, Kingston, Pa.; 1203 Macklind Ave., St. Louis 10, Mo.; 1626 Wazee St., Denver 2, Colo. ADV., pp 208 and 209
Joyce-Cridland Co., 2027 East 1st St., Dayton, Ohio
Judsen Rubber Works, Inc., 4107 West Kinzie St., Chicago 24, Ill.

K

K W Dart Truck Co., 2623 Oak St., Kansas City 8, Mo., ADV. p 184
Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Ill.
Kalamazoo Div., The New York Air Brake Co., 9000 E. Michigan Ave., Kalamazoo, Mich.
Kanawha Mfg. Co., Charleston 26, W. Va.
Keasbey & Mattison Co., Ambler, Pa.
Keenan Oil Co., Parkway Dr., Cincinnati 12, Ohio
Kelly Mfg. Co., Machine Parts Div., 503-505 Broad St., Charleston 21, W. Va.
Kennametal, Inc., Mining Tool Div. Bedford, Pa. ADV. Insert, pp. 17, 18, 19 and 20
Kennedy Valve Mfg. Co., Elmira, N. Y.
Kennedy Van Saun Mfg. & Eng. Corp., 405 Park Ave., New York 22, N. Y.
Kensington Steel, Div. of Poor & Co., 505 Kensington Ave., Chicago 28, Ill., ADV. p 259
Kern Instruments, Inc., 120 Grand St., White Plains, N.Y.
Kersey Manufacturing Co., Inc., P. O. Box 151, Bluefield, Va.
Keystone Carbon Co., 1935 State St., St Marys, Pa.
Keystone Lubricating Co., 21 & Clearfield Sts., Philadelphia 32, Pa.
Walter Kidde & Co., Inc., 357 Main St., Belleville 9, N. J.
King Powder Co., Inc., 1703 First National Bank Bldg., Cincinnati 1, Ohio
S. P. Kinney Engineers, Inc., 201 Second Ave., Carnegie, Pa.
Kinney Mfg. Div., The New York Air Brake Co., 3529 Washington St., Boston 30, Mass.
Kirk & Cowin, Inc., 1 18th St., SW, Birmingham, Ala.
Koehring Div. of Koehring Co., 3826 W. Concordia Ave., Milwaukee 16, Wis.
Koppers Co., Inc., Metal Products Div., 200 Scott St., Baltimore 3, Md.
Koppers Co., Inc., Wood Preserving Div., 750-A Koppers Bldg., Pittsburgh 19, Pa., ADV. p 255
L. O. Koven & Bro., Inc., 154 Ogden Ave., Jersey City 7, N. J.
Kremser & Sons, Inc., Frank A., P. O. Box 6207, Holmesburg Station, Philadelphia 36, Pa.
Kuhlman Elec. Co., 2565 E. Maple Rd., P. O. Box 288, Birmingham, Mich.

L

Laboratory Equipment Corp., St. Joseph, Mich.
LaBour Co., Inc., 1607 Sterling Ave., Elkhart, Ind.
Laclede Stoker Co., 4444 Hunt Ave., St. Louis 10, Mo.
Ladish Co., 5841 S. Packard Ave., Cudahy, Wis.
Lancaster Pump & Mfg. Co., Inc., Lancaster, Pa.
Laubenstein Mfg. Co., Ashland, Pa.
Layne & Bowler, Inc., Box 6697, Hollywood Sta., Memphis 8, Tenn.
Layne & Bowler Pump Co., P. O. Box 6991, Los Angeles 22, Calif.
Lecco Machinery & Engineering Co., P. O. Box 1337, New Airport Rd., Bluefield, W. Va.
Ledeen Mfg. Co., 3350 No. Gilman Rd., El Monte, Calif.
Lee-Norse Co., Charleroi, Pa.
The Leetonia Tool Co., 142 Main St., Leetonia, Ohio
Leman Machine Co., S. Railroad St., Portage, Pa., ADV. p 227
Le Roi Div., Westinghouse Air Brake Co., Milwaukee 1, Wis.
Leschen Wire Rope Div., H. K. Porter Co., Inc., 2727 Hamilton Ave., St. Louis 12, Mo., ADV. p 271
LeTourneau-Westinghouse Co., 2301 N.E. Adams St., Peoria, Ill., ADV. p 235 and 237
Linatex Corp. of America, Drawer "D" Stafford Springs, Conn., ADV. p 186
The Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio
Lincoln Engrg. Co., Div. of McNeil Mach. & Engrg. Co., 5701 Natural Bridge Ave., St. Louis 20, Mo., ADV. p 213
Link-Belt Co., Dept. CAMGL-58, Prudential Plaza, Chicago 1, Ill., ADV. Fourth Cover
Link-Belt Speeder Corp., Cedar Rapids, Iowa
Lippmann Engrg. Works, Inc., 4603 West Mitchell St., Milwaukee, Wis.
Herbert S. Littlewood, R. D. 3, Irwin, Pa.
Peter F. Loftus Corp., First National Bank Bldg., Pittsburgh 22, Pa.
The Long Co., P. O. Box 331, Oak Hill, W. V., ADV. p 179
Lubriplate Div., Fiske Brothers Refining Co., 129 Lockwood St., Newark 5, N. J.
Ludlow Saylor Wire Cloth Co., 634 South Newstead, St. Louis, 10, Mo., ADV. p 223
Ludlow Valve Mfg. Co., Inc., P. O. Box 388, Troy 1, N. Y.
Lufkin Rule Co., 1730 Hess Ave., Saginaw, Mich.
The Lunkenheimer Co., Beekman St. and Waverly Ave., Cincinnati 14, Ohio.

M

Mack Trucks, Inc., 1355 West St., Plainfield, N. J.
Macwhyte Wire Rope Co., 2931 14th Ave., Kenosha, Wis.
Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.
Magnetic Engrg. & Mfg. Co., 851 Van Houten Ave., Clifton, N. J.
Majac, Inc., Sub. of Blackstone Corp., 23rd St., Sharpsburg, Pittsburgh 15, Pa.
Manheim Mfg. & Belting Co., 470 Stiegel St., Manheim, Pa.
Manitowoc Engineering Corp., S. 16th St., Manitowoc, Wis., ADV. p 183
Charles E. Manning Co., 4700 Clairton Blvd., Pittsburgh 36, Pa., ADV. p 252
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Div., Muskegon, Mich.
Manzel Div., Houdaille Industries, Inc., 315 Babcock St., Buffalo 10, N. Y.

Marathon Coal Bit Co., Inc., Box 391, Montgomery, W. Va.
Marietta Concrete Corp., Box 356, Marietta, Ohio
Marietta Mfg. Co., Point Pleasant, W. Va.
Marion Handle Mills, Inc., Marion, Va.
Marion Metal Products Co., Chaney Ave., Marion, Ohio
Marion Power Shovel Co., a div. of Universal Marion Corp., Marion, Ohio
Marland One-Way Clutch Co., Elm Ave. & Washington St., La Grange, Ill.
Marlin-Rockwell Corp., 402 Chandler St., Jamestown, N.Y.
Marlow Pumps, Div. of Bell & Gossett Co., Box 200, Midland Park, N. J.
Marman Div., Aeroquip Corp., 11214 Exposition Blvd., Los Angeles 64, Calif.
E. F. Marsh Engrg. Co., 4324 W. Clayton Ave., St. Louis 10, Mo.
Martin Engrg. Co., Cab Road, Neponset, Ill.
Martindale Electric Co., 1307 Hird Ave., Cleveland 7, Ohio
Master Bronze Powder Co., Inc., 538-548 W. State St., Calumet City, Ill.
The Master Electric Co., Div. of Reliance Electric & Engrg. Co., 126 Davis Ave., Dayton 1, Ohio
Mayo Tunnel & Mine Equipment, Lancaster, Pa.
McDowell Co., Inc., 3203 West 71st St., Cleveland 2, Ohio
McDowel Mfg. Co., Pittsburgh 9, Pa.
McLanahan & Stone Corp., Hollidaysburg, Pa., ADV. p 229
McLaughlin Mfg. Co., Inc., 801 E. Cass St., Joliet, Ill.
McNally-Pittsburg Mfg. Corp., 307 West Third St., Pittsburg, Kan., ADV. Insert, pp 181 and 182
Meckum Engr. Co., 53 W. Jackson Blvd., Chicago 4, Ill.
John F. Meissner Engineers, Inc., 300 W. Washington St., Chicago 6, Ill.
Merrick Scale Mfg. Co., 184 Autumn St., Passaic, N. J., ADV. p 256
Metal Carbides Corp., 6001 Southern Blvd., Youngstown 12, Ohio
Metal & Thermit Corp., Rahway, N. J.
Metallurgical Products Dept., General Electric Co., Box 237, Roosevelt Park Annex, Detroit 32, Mich.
Mexico Refractories Co., Mexico, Mo.
Midland Pipe & Supply Co., 2829 S. 61st St., Chicago, Ill.
Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh 8, Pa., ADV. pp 12-13
Mine Ventilation Systems, Inc., P. O. Box 382, Madison, W. Va.
Miners' Hardware Supply Co., 821 Moravian Way, Pittsburgh 12, Pa., ADV. p 222
Mining Machine Parts Inc., 2701 St. Clair Ave., Cleveland 14, Ohio
Mining Progress, Inc., P. O. Box 3, Highland Mills, N. Y.
Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne and Windrim Aves., Phila. 44, Pa.
Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.
Mitchell Industrial Tire, Inc., Box 468, Chattanooga, Tenn.
Mobile Aerial Towers, Inc., 1730 N. Harrison St., Fort Wayne, Ind.
Mobile Drilling Inc., 960 North Pennsylvania, Indianapolis 4, Ind., ADV. Insert, pp 199 and 200
Moloney Electric Co., 5390 Bircher Blvd., St. Louis 20, Mo.
Monsanto Chemical Co., Organic Chemicals Div., Lindbergh and Olive, Rd., St. Louis 24, Mo.
The Moore Co., 1036 Quarrier St., Charleston, W. Va.
Morris Machine Works, Baldwinsville, N. Y., ADV. p 273
Morse Bros. Machinery Co., 2900 Brighton Blvd., Denver 1, Colo.
Morse Chain Co., A Borg-Warner Industry, Ithaca, N.Y.
Morton Salt Co., 110 No. Wacker, Chicago 6, Ill.
Mosebach Electric & Supply Co., 115 Arlington Ave., Pittsburgh 3, Pa.
T. J. Moss Tie Co., 700 Security Bldg., St. Louis 2, Mo.
Motor Exchange and Supply Co., Hines, W. Va., ADV. p 280
Motorola Communications & Electronics, Inc., 4501 West Augusta Blvd., Chicago 51, Ill.
Mott Core Drilling Co., 830 Eighth Ave., Huntington 17, W. Va.
Murphy Diesel Co., 5317 West Burnham St., Milwaukee, Wis.
Myers-Whaley Co., P. O. Box 789, Knoxville 1, Tenn., ADV. p 264

N

Nachod & U. S. Signal Co., 4777 Louisville Ave., Louisville 9, Ky., ADV. p 280
Nagle Pumps, Inc., 1237 Center Ave., Chicago Heights, Ill.
Nash Engineering Co., South Norwalk, Conn.
Nathan Mfg. Corp., 45-02 Ditmars Blvd., Long Island City 5, N. Y.
National Air Vibrator Co., 2364 W. Seventh St., Cleveland 13, Ohio
National Carbon Co., Division of Union Carbide Corp., 30 East 42nd St., New York 17, N. Y.
National Electric Coil Co., 800 King Ave., Columbus 16, Ohio
National Electric Products Co., Gateway Center, Bldg. 2, 140 Stanwix St., Pittsburgh 22, Pa.
National Filter Media Corp., 1717 Dixwell Ave., New Haven 11, Conn.
National Malleable & Steel Castings Co., 10600 Quincy Ave., Cleveland 6, Ohio, ADV. Second Cover
National Mine Service Co., 1260 Maple St., Indiana, Pa.; Clarkson Div., Nashville, Ill.; Bemeco Div., Beckley, W. Va.; All-State Div., Logan, W. Va.; Kentucky-Virginia Div., Jenkins, Ky.; Whiteman Div., Indiana, Pa. and Morgantown, W. Va.; Ashland Div., Ashland, Ky.; Anthracite Div., Forty Fort, Pa.; Western Kentucky Div., Madisonville, Ky.; Greensburg Div., Greensburg, Pa.
National Powder Co., Eldred, Pa.
National Supply Company, 2 Gateway Center, Pittsburgh, Pa.
National Tube Div., United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa.
Naylor Pipe Co., 1262 E. 92 St., Chicago 19, Ill.
Neff & Fry Co., 227 Elm St., Camden, Ohio
Newcomer Products, Inc., Latrobe, Pa.
New Departure Div., General Motors Corp., Bristol, Conn.
New Jersey Meter Co., Plainfield, N. J.
New York & New Jersey Lubricant Co., 292 Madison Ave., New York 17, N. Y.
Newark Wire Cloth Co., 351 Verona Ave., Newark 4, N. J.
The Nolan Co., Bowerston, Ohio, ADV. p 189
Nordberg Mfg. Co., 3073 South Chase Ave., Milwaukee 1, Wis.
Norma-Hoffman Bearing Corp., Stamford, Conn.
Northwest Engineering Co., 135 S. La Salle St., Chicago 3, Ill.
Norton Co., 1 New Bond St., Worcester 6, Mass.
B. J. Nykerk Corp., 42 Broadway, New York 4, N. Y.

O

Ohio Brass Co., Mansfiled, Ohio
Ohio Carbon Co., 12508 Berea Road, Cleveland 11, Ohio
Ohio Oil Co., Findlay, Ohio
Okonite Co., Canal St., Passaic, N. J.
Olin-Mathieson Chemical Corp., Explosives Div. East Alton, Ill.
The Oliver Corp., 400 West Madison St., Chicago 6, Ill.
Onox, Inc., 121 Second St., San Francisco 5, Calif.
The Ore & Chemical Corp., 80 Broad St., New York, N. Y.
Ore Reclamation Co., 301 No. Connell Ave., Pichner, Okla.
Orefraction, Inc., 7425 Thomas St., Pittsburgh 8, Pa.
Orton Crane & Shovel Co., 608 S. Dearborn St., Chicago 5, Ill.
Osmose Wood Preserving Co., 980 Ellicott St., Buffalo 9, N. Y.

P

Page Engineering Co., Clearing Post Office, Chicago 38, Ill.
Page Steel & Wire Div., American Chain & Cable Co., Inc., Monessen, Pa.
The Palnut Co., Glen Road, Mountainside, N. J.
Paltech Co., 85 Spring St., South Norwalk, Conn.
Pangborn Corp., 670 Pangborn Blvd., Hagerstown, Md.
Paris Mfg. Co., Paris, Ill.
Parker Fittings & Hose Div. and Parker Hydraulics Div., 17325 Euclid Ave., Cleveland 12, Ohio
The Parkersburg Rig & Reel Co., Div. of Parkersburg-Aetna Corp., 1958 Crawford St., Parkersburg, W. Va.
Pattin Mfg. Co., Marietta, Ohio
Peerless Photo Products, Shoreham, N. Y.
Peerless Pump Div., Food Machinery & Chemical Corp., 301 West Ave. 26, Los Angeles 31, Calif.
Penn Machine Co., 106 Station St., Johnstown, Pa.
Pennsylvania Crusher Div., Bath Iron Works Corp., Room 1711 West Chester, Pa.
Pennsylvania Drilling Co., 1201 Chartiers Ave., Pittsburgh 20, Pa.; Masonry Drill Div., 1201 Banksville Rd., Pittsburgh 16, Pa.
Pennsylvania Electric Coil Corp., 1301 Saw Mill Run Blvd., Pittsburgh 26, Pa.
Pennsylvania Pump & Compressor Co., Easton, Pa.
Pennsylvania Refining Co., Butler, Pa.
Perfection Steel Body Co., East St., Galion, Ohio
Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.
The Permutit Co., a div. of Pfaudler Permutit Inc., 50 West 44th St., New York 36, N. Y.
Peterson Filters & Engineering Co., 1949 S. Second West, Salt Lake City, Utah
J. B. Pfister Co., 662 Ohio St., Terre Haute, Ind.
Phelps Dodge Copper Products Co., 300 Park Ave., New York 22, N. Y.
Phoenix Iron & Steel Co., Structural & Tube Divisions, Phoenixville, Pa.; Plate Div., Harrisburg, Pa., Phoenix Bridge Co., Phoenixville Pa.
Phoenix Products Co., Inc., 4737 North 27th St., Milwaukee 9, Wis.
Pierce Management Corp., P. P. & L. Bldg., Scranton, Pa.
Pioneer Engineering, Div. of Poor & Co., 3200 Como Ave., Minneapolis 14, Minn.
Pipe Linings, a Div. of American Pipe and Construction Co., P. O. Box 457, Wilmington, Calif.
Pitman Manufacturing Co., 300 West 79th Terrace, Kansas City 14, Mo.
Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Gear Co., Neville Island, Pittsburgh 25, Pa.
Pittsburgh Plate Glass Co., One Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Screw & Bolt Corp., P. O. Box 1708, Pittsburgh 30, Pa.
Plymouth Locomotive Works, Div. of the Fate-Root-Heath Co., Plymouth, Ohio
Plymouth Rubber Co., Inc., 51 Revere St., Canton, Mass.
H. K. Porter Co., Connors Steel Div., West Virginia Works, P. O. Box 118, Huntington, W. Va., Connors Works, P. O. Box 2562, Birmingham, Ala.
H. K. Porter, Inc. 74 Foley St., Somerville, Mass.
Porto Pump, Inc. 19735 Ralston, Detroit 3, Mich.
The Post Glover Electric Co., P. O. Box 709, Covington, Ky.
Preco Incorporated, 6300 E. Slauson Ave., Los Angeles 22, Calif.
Prime Mover Co., Muscatine, Iowa
K. Prins & Associates, Wellston, Ohio
Productive Equipment Corp., 2926 West Lake St., Chicago 12, Ill.
Proto Tool Co., Div. of Pendleton Tool Industries, Inc., 2209 Santa Fe Ave., Los Angeles, Calif.
Frank Prox Company, Inc., 1201 South 1st St., Terre Haute, Ind.
Pulmosan Safety Equip. Co., 644 Pacific St., Brooklyn, N. Y.
Pure Carbon Co., Inc., 441 Hall Ave., St. Marys, Pa.
The Pure Oil Co., 620 E. Broad St., Columbus, Ohio

Q

Quaker Rubber Div., H. K. Porter Co. Inc., Tacony & Comly Streets, Phila. 24, Pa.

"Quick-Way" Truck Shovel Co., 2401 E. 40th Ave., Denver, Colo.

R

R-P & C Valve Div., American Chain & Cable Co., Inc., Reading, Pa.
Raybestos Manhattan, Inc., Manhattan Rubber Div., 42 Townsend t., Passaic, N. J.
Read, Davis, 120 S. La Salle St., Chicago, Il.
Red Jacket Co., Inc., 500 Bell Ave., Carnegie, Pa.
Reeves Pulley Co. Div., The Reliance Electric & Engineering Co., 1225 7th St., Columbus, Ind.
Reich Bros. Mfg. Co., Inc., 1439 Ash St., Terre Haute, Ind.
Reid Belt & Rubber Co. Inc., 917 Grant St., Bluefield, W. Va.
Geo. P. Reintjes Co., P. O. Box 856, Kansas City 41, Mo.
Reliance Elec. & Eng. Co., 24701 Euclid Ave., Cleveland 17, Ohio
Reliance Insurance Co., 401 Walnut St., Philadelphia 6, Pa.
Remaly Mfg. Co., Inc., Tamaqua, Pa.
Remington Arms Co., Inc., 939 Barnum Ave., Bridgeport 2, Conn.
Reo Div., The White Motor Co., 1331 South Washington St., Lansing 20, Mich.
Republic Creosoting Co., 1615 Merchants Bank Bldg., Indianapolis 4, Ind.
Republic Rubber Div., Lee Rubber & Tire Co., Youngstown 1, Ohio
Republic Steel, Republic Bldg., Cleveland 1, Ohio
Resisto-Loy Co., Inc., 1251 Phillips Ave., S.W., Grand Rapids 7, Mich.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.
Reynolds Metals Co., 2500 South Third St., Louisville 1, Ky.
Rice Pump & Machine Co., Belgium, Wis.
The Ridge Tool Co., 400 Clark St., Elyria, Ohio
Riegel Textile Corp., 260 Madison Ave., New York, N. Y.; Glove Div., Conover, N.C.
Robbins & Myers, Inc., 1345 Lagonda Ave., Springfield, Ohio
Roberts & Schaefer Co., Sub. Thomoson-Starrett Co., Inc., 130 N. Wells St., Chicago 6, Ill., ADV. p 279
Robinson & Robinson, Union Bldg., Charleston, West Va.
Robinson Ventilating Co., Zelienople, Pa.
Rochester Ropes Inc., Culpeper, Va.
Rockbestos Products Corp., Nicoll and Canner Sts., New Haven 4, Conn.
Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.
Rockwell-Standard Corp. Brake Div., Ashtabula, Ohio
John A. Roebling's Sons Corp., Sub. Colorado Fuel & Iron Corp., 640 South Broad St., Trenton 2, N. J.
Rollway Bearing Co., Inc., 541 Seymour St., Syracuse 4, N.Y.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Roots-Connersville Blower Div., Dresser Industries, Inc., 900 W. Mount St., Connersville, Ind.
Ross Screen & Feeder Co., 100 Quimby St., Westfield, N. J.
The Ruberoid Co., 500 Fifth Ave., New York 36, N. Y.
Ruger Equipment, Inc., 615 W. 4th St., Uhrichsville, Ohio
Rust-Oleum Corp., 2425 Oakton St., Evanston, Ill.
Rydin Railway Equip. Co., 224 S. Mighigan Ave., Chicago 4, Ill.
Joseph T. Ryerson & Son, Inc., 16 & Rockwell Sts., P. O. Box 8000A, Chicago 80, Ill.

S

SKF Industries, Inc., P. O. Box 6731, Philadelphia 32, Pa.
Salem-Brosius, Inc., P. O. Box 2222, Pittsburgh 30, Pa.
The Salem Tool Co., 767 S. Ellsworth Ave., Salem, Ohio, ADV. p 191
Sanford Day Iron Works, Inc., P. O. Box 1511, Knoxville 9, Tenn.
Sauerman Bros., Inc., 620 South 28th Ave., Bellwood, Ill.
W. J. Savage Co., 912 Clinch Ave., S.W., Knoxville 2, Tenn.
Scandinavia Belting Co., P. O. Box 464, Newark 1, N. J., ADV. p 2
Schaffer Poidometer Co., 2828 Smallman St., Pittsburgh 22, Pa.
Schield Bantam Co., 221 Park St., Waverly Iowa
Schramm Inc. 870 E. Virginia Ave. West Chester Pa.
Schroeder Bros. Corp., Nichol Ave., Box 72, McKees Rocks, Pa.
Scientific Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.
Scranton Electric Construction Co., 625 Connell Bldg., Scranton, Pa.
Screen Equipment Co., Inc., Buffalo 25, N. Y.
Sheffield Div., Armco Steel Corp., Sheffield Sta., Kansas City, Mo.
Shell Oil Co., 50 W. 50th St., New York, N. Y.
Shepard Niles Crane & Hoist Corp., Schuyler Ave., Montour Falls, N. Y.
R. H. Sheppard Co., Inc. Hantour Falls, N. Y.
Shirley Machine Co., 725 Liberty Ave., Pittsburgh 22, Pa., ADV. p 275
The Sight Feed Generator Co., 38 E. Third St., West Alexandria, Ohio
Sika Chemical Corp., 33-47 Gregory Ave., Passaic, N. J.
Silver Engineering Works, Inc., 3309 Blake St., Denver 5, Colo.
Simonds Saw & Steel Co., 470 Main St., Fitchburg, Mass.
Simplex Wire & Cable Co. 79 Sidney St., Cambrige 39, Mass.
Simplicity Engineering Co., Durand, Mich.
Sinclair Refining Co., 600 Fifth Ave., New York 20, N. Y.
Slip-On, Inc., 401 Broadway, New York 13, N. Y.
The W. W. Sly Manufacturing Co., 4772 Train Ave., Cleveland 1, Ohio
J. K. Smit & Sons, Inc., Murray Hill, N. J.
H. C. Smith Tool Co., P O. Box 431, Compton, Calif.
Smith Engineering Works, 502 East Capitol Dr., Milwaukee, Wis.
Snap-On Tools Corp., 8132 28 Ave., Kenosha, Wis.
The Snow-Nabstedt Gear Corp., 251 Welton St., Hamden 7, Conn.
Socony Mobil Oil Co. Inc., 150 E. 42nd St., New York 17, N. Y.
Solvay Process Div., Allied Chemical Corp., 61 Broadway, New York 6, N. Y.
South Bend Lathe Works, 425 E. Madison St. South Bend 22, Ind.
Southwestern Engineering Co., P. O. Box 58264, Vernon Station, Los Angeles 58, Calif.
Spang & Company, P. O. Box 751, Butler, Pa.
Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo.
Sprague & Henwood Inc., 221 W. Olive St., Scranton Pa.
W. F. Sprengnether Instrument Co., Inc., 4576 Swan Ave., St. Louis 10, Mo.
Sprout Waldron & Co., Inc., Muncy, Pa.
Stackpole Carbon Co., Stackpole St., St. Marys, Pa.
The W. R. Stamler Corp., Paris, Ky.
Standard Carbon Co., P. O. 49, Steubenville, Ohio
Standard Devices Co., 3231 Warrensville Center, Cleveland 22, Ohio
Standard Oil Co. (Ind.), 910 South Michigan Ave., Chicago 80, Ill.
Standard Steel Corp., 5001 S. Boyle Ave., Los Angeles 58, Calif.
Star Jack Co., Inc., 420 Lexington Ave., New York 17, N. Y.
Stardrill-Keystone Co., 920-17th St., Beaver Falls, Pa., ADV. p 257
Stearn Magnetic Products, 635 So. 28th St., Milwaukee 46, Wis.
The Stearns-Roger Mfg. Co., 660 Bannock St., P. O. Box 5370, Denver 17, Colo.
Stedman Foundry & Machine Co., Inc., Aurora, Ind.
Steel-Bilt Construction Co., P. O. Box 309, Bridgeville, Pa.
Steelcraft Mfg. Co., 9017 Blue Ash Rd., Cincinnati 42, Ohio
Stephens-Adamson Mfg. Co., 2 Ridgeway Ave., Aurora, Ill.
Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.
Sterling Steel Casting Co., P. O. Box 230, East St. Louis, Ill.
Stewart-Warner Corp., Alemite Div., 1826 Diversey Pkway., Chicago 14, Ill.
Stonhard Co. Inc., 1306 Spring Garden St., Philadelphia 23, Pa.
Stoody Co., 11928 East Slauson Ave., Whittier, Calif.
Straub Mfg. Co., Inc. 8383 Baldwin St., Oakland 21, Calif.
Stulz-Sickles Co., 929-939 Port Ave. At Julia St., Elizabeth, N.J.
Sturtevant Mill Co., 103 Clayton St., Dorchester, Boston 22, Mass.
Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa., ADV. 14 and 15
Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio.
Peter O. Sutphen, P.O. Box 58, Everett, Pa.
Swan-Finch Petrochemicals 5849 W. 66th St., Chicago, Ill.
Syntron Co., 975 Lexington Ave., Homer City, Pa.

T

Talk-A-Phone 1514 S. Pulaski Rd., Chicago 23, Ill.
Talcott, Inc., 91 Sabin St., Providence 1, R.I.
Taller & Cooper, Sub. of American Electronics, Inc., 75 Front St., Brooklyn, N.Y.
Tamping Bag Co. Div., Pickard Industries, Inc., Mt. Vernon, Ill.
Taylor-Wharton Co. Div., Harsco Corp., High Bridge, N.J.
Templeton, Kenly & Co., 16th & Gardner Rd., Broadview, Ill., ADV. p 278
Templeton-Matthews Corp., 905 Sycamore Bldg., Terre Haute, Ind.
The Texas Co., 135 East 42nd St., New York 17, N.Y., ADV. p 4 and 5
Thermoid Co., Trenton, N.J.
The Thew Shovel Co., Lorain, Ohio.
Thomas Engineering & Construction Co., Box 646, Greensburg, Pa.
Thomas Flexible Coupling Co., Main Ave. and Biddle St., Warren, Pa.
Thor Power Tool Co., Prudential Plaza, Chicago 1, Ill.
Thurman Scale Co., Div. Thurman Mfg. Co., 156 North Fifth St., Columbus, Ohio
Tidewater Oil Co., 17 Battery Pl., New York 4, N.Y.
The Timken Roller Bearing Co., 1835 Dueber Ave., S.W., Canton 6, Ohio
Toledo Pipe Threading Machine Co., 1445 Summit Ave., Toledo 4, Ohio
The Tool Steel Gear & Pinion Co., 211 Township Ave., Cincinnati 16, Ohio
Torrington Co., 59 Field St., Torrington, Conn.
Trabon Engineering Corp., 28815 Aurora Rd.,Solon, Ohio
Tractomotive Corp., Box 632, County Line Rd., Deerfield, Ill.
Bertrand P. Tracy Co., 919 Fulton St., Pittsburgh 12, Pa.,
Transmission & Axle Div., Rockwell-Standard Corp., Detroit 32, Mich.
Transall, Incorporated, P. O. Box 1588, 109 North 11 St., Birmingham 4, Ala.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Triangle Conduit & Cable Co., Inc., Box 711, Triangle & Jersey Aves., New Brunswick, N.J.
Tri-County Building Service, P. O. Box 405, Taylorville, Ill.
Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee 12 Wis.
Truck Engineering Corp., 1285 W. 70th St., Cleveland 2, Ohio
Tube Turns, Div., National Cylinder Gas Co., 224 E. Broadway, Louisville 1, Ky.
Tweco Products, Inc., 1450 South Mosley, Wichita 1, Kan.
Twin Disc Clutch Co., Racine, Wisc.; Hydraulic Div. and Export Div., Rockford, Ill.
W. S. Tyler Co., 3615 Superior Ave., Cleveland 14, Ohio
Tyson Bearing Corp., Div. of SKF Industries, Inc., Massillon, Ohio.

U

Union Switch & Signal Div. of Westinghouse Air Brake Co., Pittsburgh 18, Pa., ADV. p 1
Union Wire Rope Corp., Sub. of Armco Steel Corp., 2100 Manchester Ave., Kansas City 26, Mo.
Unit Crane & Shovel Corp., 6411 West Burnham St., Milwaukee 19, Wisc.
U.S. Electrical Motors, Inc., 200 East Slauson Ave., Los Angeles 54, Calif.

United States Pipe & Foundry Co., 3300 First Ave., N. Birmingham 2, Ala.
United States Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y., ADV. p 6
United States Safety Service Co., 1535 Walnut St., Kansas City 8, Mo.
United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa. ADV. p 204 and 205
Universal Engineering Corp., 625 "C" Ave., Northwest, Cedar Rapids, Iowa
Universal Road Machinery Co., Kingston, N.Y.
Universal Vibrating Screen Co., Deane Blvd. & St. Paul R.R., Racine, Wisc.
Upson-Walton Co., 12515 Elmwood Ave., Cleveland 11, Ohio
Utility Mine Equipment Co., 1010 Collingwood Rd., St. Louis 24, Mo.

V

Valve Div., Thompson Products, Inc., 455 E. 185th St., Cleveland 10, Ohio
Valvoline Oil Co., Div. of Ashland Oil & Refining Co., Freedom, Pa.
R. T. Vanderbilt Co., Inc., 230 Park Ave., New York, N. Y.
Varel Mfg. Co., Inc., 9230 Denton Dr., P. O. Box 13146 Dallas 20, Texas
Vascoloy-Ramet Corp., 800 Market St., Waukegan, Ill.
Viber Co., 726S. Flower St., Burbank, Calif.
Vibration Measurement Engineers, Inc., 725 Oakton Ave., Evanston, Ill.
Vickers Incorporated, Administrative & Engineering Center Detroit, 32, Mich.
Vickers, Inc., Tulsa Winch Div., 815 East First St., Tulsa 20, Okla.
Victaulic Co. of America, Box 509, Elizabeth, N. J., ADV. p 232
Viking Machinery Sales Corp., 205 O'Brien Rd., Jackson, Mich.
Visking Co., Plastics Div., P. O. Box 1410, Terre Haute, Ind.
Vulcan Iron Works, 730 South Main St., Wilkes Barre, Pa.

W

Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 14, Mo.
Wall Colmonoy Corp., 19345 John R. St., Detroit 3, Mich.
Walworth Co., 60 East 42nd St., New York 17, N. Y.
Warn Mfg. Co., Riverton Box 6064, Seattle 88, Wash., ADV. p 270.
Warner Laboratories, Inc., Cresson, Pa., ADV. p 238
Warren Refining & Chemical Co., 5151 Denison Ave., Cleveland 2, Ohio
Watt Car & Wheel Co., Barnesville, Ohio
Waukesha Motor Co., West St. Paul Ave., Waukesha, Wis.
Weatherhead Co., Fort Wayne Div., 128 W. Washington Blvd., Fort Wayne, Ind.
Webster Mfg., Inc., Tiffin, Ohio
Wedge Wire Corp., Gas St. & N.P.R.R., Wellington, Ohio,
Paul Weir Co., Inc. 20 N. Wacker Drive Chicago 6, Ill.
S. K. Wellman Co., 200 Egbert Rd., Bedford, Ohio
West Instrument Corp., 4363 W. Montrose Ave., Chicago 41, Ill.
West Virginia Armature Co., Bluefield, W. Va.
West Virginia Belt & Cable Repairs, Inc., P. O. Box 32, Mount Hope, W. Va.
Western Insulated Wire Co., Los Angeles 58, Calif.
Western Machinery Co., 650 Fifth St., San Francisco 7, Calif., ADV. p 289
Western Precipitation Corp., 1000 West Ninth St., Los Angeles 54, Calif.
Westinghouse Electric Corp., 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.
Westinghouse Electric Corp., B. F. Sturtevant Div., Hyde Park, Boston, Mass.
Wheelabrator Corp., 1050 South Byrkit St., Mishawaka, Ind.
Wheeler Electronic Corp., Sub. of Sperry Rand Corp., 150 East Aurora St., Waterbury, Conn.
White Diesel Engine Div., The White Motor Co., Springfield, Ohio
The Whitmore Mfg. Co., Drawer 1640, Station C, Cleveland 4, Ohio.
Whiting Corp., Harvey, Ill.
Whitney Chain Co., 237 Hamilton St., Hartford 2, Conn.
Wilbur & Williams Co., 130 Lincoln St., Brighton, Boston 35, Mass.
Wilcox Mfg. Co., P. O. Box 217, Raleigh, W. Va.
Wild Heerbrugg Instruments, Inc., Main & Covert Sts., Port Washington, N. Y.
Wiley Mfg. Co., Port Deposit, Md.
A. R. Wilfley & Sons, P. O. Box 2330, Denver 1, Colo.
Williams Patent Crusher & Pulv. Co., 810 Montgomery St., St. Louis 6, Mo.
Wilmot Engineering Co., 8 West Broad St., Hazelton, Pa., ADV. p 287
L. J. Wing Mfg. Co., Div. of Aero Supply Mfg. Co., Inc., 303 Vreeland Mills Rd., Linden, N. J.
Winslow Government Standard Scale Works, Inc., 25 & Haythorne Sts., Terre Haute, Ind.
Winter-Weiss Co., 2201 Blake St., Denver 5, Colo. ADV. p 228
Wire Rope Corp. of America, Inc., 609 North Second St., St. Joseph, Mo.
Wisconsin Motor Corp., Milwaukee 46, Wis.
Wise Co., O. B., P. O. Box 42, West End & Dale Ave., Knoxville 1, Tenn.
The Wood Shovel & Tool Co., Lock Drawer 818, Piqua, Ohio
T. B. Woods Sons Co., Chambersburg, Pa.
J. W. Woomer & Associates, 821 Oliver Bldg., Pittsburgh 22, Pa.
Worthington Corp., 421 Worthington Ave., Harrison, N. J.
Wright Power Saw & Tool Corp., Sub. of Thomas Industries, Inc., 1419 Illinois Ave., Sheboygan, Wisc.
Wyandotte Chemicals Corp., Michigan Alkali Div., Wyandotte, Mich.
Wysmont Co., Inc., 42/07 27th St., Long Island City 1, N. Y.

Y

Yale & Towne Mfg. Co., 11000 Roosevelt Blvd., Philadelphia 15, Pa.
Yardley Plastics Co., 142 Parsons Ave., Columbus 15, Ohio
Yardney Electric Corp., 40 Leonard St., New York 13, N. Y.
Youngstown Sheet & Tube Co., Youngstown 1, Ohio

Z

J. A. Zurn Mfg. Div., Zurn Industries, Inc. 1960 Pittsburgh Ave., Erie, Pa.
Zurn Industries, Inc. Mechanical Power Transmission Div., 1960 Pittsburgh Ave., Erie, Pa.

Guidebook Advertisers' District Sales Offices Distributors and/or Sales Agents

Listed Geographically for Easy Reference

This listing of sales offices, distributors and/ or sales agents is designed to help Guidebook users quickly locate their nearest source of supply for manufacturers advertising in this issue. A company name in black-faced type in the Classified Product Directory (page 185) notes that more information on products offered by that manufacturer is available in advertisements on pages listed in the Directory of Manufacturers or in the Advertisers' Index on page 316.

A

AEROQUIP CO.

Jackson, Michigan

DISTRICT SALES OFFICES

North Carolina, Greensboro: Cross Sales & Engineering Co., P.O. Box 794, 317 W. Lee St., Phone 4-1947

DISTRIBUTORS

Alabama, Birmingham: Cummins Diesel Sales, 931 N. 7th Ave. Mill & Mine Supply Co., 124 S. 20th St.
Mobile: Allied Auto Parts, 265 St. Louis St.
Montgomery: Dixie Trailer & Brake Service, 1625 Bell St.
Illinois, Chicago 7: Chicago Tire & Rubber Co., 850 Washington Blvd.
Decatur: Midstate Machinery Co., 359 E. Main St.
E. St. Louis: Illinois Electric Works, Inc., 1300-10 Missouri Ave.
Indiana, Evansville 7: Hocker Power Brake Co., 3rd & Ingle at Carpenter
Kentucky, Ashland: Ashland Plant, P.O. Box 888
Jenkins: National Mine Svc., Kentucky-Virginia Div., P. O. Box 872
Madisonville: National Mine Svc., Western Kentucky Div., 132 East Center St.
Pennsylvania, Harrisburg: Safety Sales & Service Corp., P.O. Box 1129
Indiana: National Mine Svc., Whiteman Div., 1260 Maple St.
Pittsburgh 6: The Cypher Co., 1201 Washington Blvd.
Pittsburgh 3: Transmission Equipment Co., 1200 Muriel St.
Virginia, Harrisburg: Valley Distributors, Inc., 60 E. Rack St.
Portsmouth: Morse - Parker Motor Supply Co., P.O. Box 587
Norfolk: Diesel Injection Sales & Service Inc., 808 Union Tidewater Supply Co., 501 W. 24th St.
Richmond: Cummins Diesel Sales & Service, P.O. Box 9426 Standard Parts Corp., 1017 W. Graham Rd.
Roanoke: Standard Parts Corp., Williamson Rd. Tidewater Supply Co
Salem: Diesel Injection Sales & Service, Inc., 412 8th St.
Winchester: Valley Distributors Inc.
West Virginia, Beckley: National Mine Svc., Bemeco Div., P.O. Box 32
Bluefield: Bluefield Hardware Co.
Logan: National Mine Svc., All-State Div., P.O. Box 1671
Charleston: A&I Supply Co., 614 Virginia St. West Capital City Supply Co., Broad & Smith St. Cummins Diesel Sales & Svc. Inc., Box 527 Kanawha Steel & Equipment Co., Clark & Welch St.
Fairmont: Fairmont Supply Co., 10th & Belt Lane
Weirton: Kanawha Steel & Equipment Co., 112 24th St.
Wheeling: Wheeling Rubber Products Inc., 841 Market St.
Williamson: Persinger Supply Co.

ALLEGHENY LUDLUM STEEL CO., CARMET DIV.

1500 Jarvis Ave., Detroit, Mich., JOrdan 4-6900

DISTRIBUTORS

Alabama, Birmingham: Crandall Engineering Co., Inc.
Colorado, Denver: Union Supply Co.
Indiana, Evansville: Drillmaster Supply & Mfg. Co.
Michigan, Iron Mountain: W. B. Thompson Co.
New Mexico, Carlsbad: Carlsbad Supply Co.
New York, Buffalo: Brace-Mueller-Huntley, Inc.
Rochester: Brace - Mueller-Huntley, Inc.
Syracuse: Brace - Mueller-Huntley, Inc.
Ohio, St. Clairsville: Oglebay, Norton Mine Supply Div.
Oklahoma, McAlester: Gladstein Co.
Picher: Consolidated Supply Co.
Pennsylvania, Charleroi: Oglebay, Norton Mine Supply Div.
Johnstown: Oglebay, Norton Mine Supply Div.
Pittsburgh: U.S. Steel Supply Co.
Tennessee, Jellico McCombs Supply Co.
Whitewell: Marion Mine & Mill Supply Co.
Utah, Helper: Carbon Transfer & Supply Co.
West Virginia, Charleston: Persinger's Inc.
Williamson: Persinger Supply Co.

ALLEN & GARCIA CO.

322 S. Michigan Ave., Chicago 4, Ill.

ALUMINUM CO. OF AMERICA

425 6th Ave., Pittsburgh 19, Pa.

SALES OFFICES

Alabama, Birmingham 2: No. 10 Office Park, Mountain Brook, P. O. Box 2041, Tremont 9-8641
Colorado, Denver 6: 105 Filmore St., Dudley 8-1619
Illinois, Chicago 11: 520 N. Michigan Ave., Delaware 7-8181
Peoria: 725 Commercial Bank Bldg., Phone: 3-7445
Indiana, Evansville: 207 Kinkel Bldg., Harrison 2-3279
Indianapolis 7: 2939 N. Meridian St., Walnut 5-6471
Kentucky, Louisville 2: 1154 Starks Bldg., Juniper 7-7456
Missouri, Kansas City 5: 2300 Power & Light Bldg., Victor 2-2822
St. Louis 8: Continental Bldg. 10th Fl., Franklin 1-6700
Ohio, Cincinnati 6: 2331 Victory Parkway, Capital 1-7000
Cleveland 13: 1450 Terminal Tower, Cherry 1-6880
Columbus 15: 40 S. 3rd St. Bldg., Capital 4-5251
Youngstown: 537 Ohio Edison Bldg., Riverside 4-8671
Pennsylvania, Allentown: 1132 Hamilton St., Hemlock 3-7463
Philadelphia 9: 123 S. Broad St., Kingsley 5-0250
Pittsburgh 19: 1501 Alcoa Bldg., Atlantic 1-1531
York: 205 Manufacturing Bldg., 82-044
Tennessee, Chattanooga 2: 1205 Volunteer Bldg., Amhurst 7-6585
Memphis 3: 1520 Sterick Bldg Jackson 5-8305

DISTRIBUTORS

Alabama, Birmingham: Hinkle Supply Co., Inc., 2923 5th Ave. S.
Colorado, Denver: Marsh Steel Corp., 5500 Colorado Blvd.
Denver 16: Metal Goods Corp., 4343 Holly St.
Illinois, Chicago 80: Central Steel & Wire Co., P.O. Box 5310A
Chicago 80: Steel Sales Corp., 3348 S. Pulaski Rd.
Chicago 50: Corey Steel Co., 2800 S. 61st Court
Indiana, Indianapolis 18: Steel Sales Corp., 2185 N. Sherman Dr.
Missouri, N. Kansas City: Marsh Steel Corp., 101 E. 9th St.
N. Kansas City: Metal Goods Corp., 1300 Burlington Ave.
St. Louis 14: Metal Goods Corp., 8800 Page Blvd.
St. Louis 10: Steel Sales Corp., 4565 McRee Av.

Continued

Ohio, Cincinnati 29: Williams & Co., Inc., 3231 Fredonia Ave.
Cincinnati 14: Central Steel & Wire Co., Box 148 Annex Station
Cleveland 2: Nottingham St & Aluminum Co., 4510 Division Ave.
Cleveland 14: Williams & Co., 3700 Perkins Ave.
Columbus 8: Williams & Co., 851 Williams Ave.
Pennsylvania, Philadelphia 34: Edgcomb Steel Co., D St.
Philadelphia 40: Whitehead Metal Products Co., Inc., 1955-75 Hunting Park Ave.
Pittsburgh 33: Williams & Co., Inc., 901 Pennsylvania Ave.
York: Edgcomb Steel Co., 420 Memory Lane
Tennessee, Memphis: Metal Goods Corp., 1970 Latham St.

AMERICAN AIR FILTER CO., INC.

Louisville 8, Ky.

DISTRIBUTORS

Illinois, Chicago 1: Air Filter & Equipment Co., 228 N. La-Salle St.
Kentucky, Louisville 2: H. M. Lutes Assoc., 633 S. 5th St.
Missouri, St. Louis 10: C. H. Burnap Co., 4030 Chouteau Ave., 312 Chouteau Bldg.
Pennsylvania, Pittsburgh 42: American Air Filter Co., Inc., 5907 Penn Ave.
West Virginia, South Charleston 24: Mechanical Products Co., 702 Jefferson Road

ACF INDUSTRIES, INC., AMERICAN CAR & FOUNDRY DIV.

750 Third Avenue New York 17, New York

DISTRICT SALES OFFICES

California, San Francisco 4: 111 Sutter St., Rm. 529
District of Columbia, Washington 6: 1625 K St., N.W.
Illinois, Chicago 4: 80 E. Jackson Blvd.
Missouri, St. Louis 1: 705 Olive St. Bldg.
Ohio, Cleveland 13: Terminal Tower Bldg.
Pennsylvania, Berwick 6: ACF Industries Inc.
Philadelphia 3: 538 Transportation Bldg., 6 Penn Center Plaza
West Virginia, Huntington 10: P.O. Box 547

AMERICAN MINE DOOR CO., THE

2057 Dueber Ave. S. W., Canton 6, Ohio, Glendale 4-7055

DISTRIBUTORS

Alabama, Birmingham: J. T. Sudduth & Co., 3017 Sixth Ave., S., Phone Alpine 2-6101
Colorado, Denver 16: Union Supply Co., 5460 Colorado Blvd., Amherst 6-2292
Kentucky, Madisonville: Robert A. Thompson, c/o Madison Hotel, Phone 812
Michigan, Ishpeming: Charter Inc., 115 S. 1st St., Hudson 6-4471
Pennsylvania, Hazleton: Barrett Haentjens Sales Co., 225 North Cedar St., Phone GL 4-0837
Utah, Salt Lake City: National Equipment Co., 101 W. 2nd S. St., Empire 3-8878

AMERICAN MINE SUPPLY CO.

404 Frick Bldg., Pittsburgh 19, Pa., Atlantic 1-7979

DISTRIBUTORS

Alabama, Birmingham 8: National Mine Service Co., 2602 15th St., Ensley
Illinois, Mt. Vernon: Central Mine Supply Co., 218 S. 3rd St.
Kentucky, Jenkins: National Mine Service Co., P.O. Box 872
Madisonville: Central Mine Supply Company 284 W. Center Street
Michigan, Ishpeming: Charter, Inc., 115 S. First St.
Minnesota, Hibbing: Charter, Inc., 2905 First Avenue
Pennsylvania: Pittsburgh 21: Wallis & Co., P. O. Box 8643
Forty-fort: National Mine Service Co., 153 Wells St.
Utah, Salt Lake City 1: Western Sales Engineering Co., 375 South West Temple
West Virginia, Beckley: National Mine Service Co., P. O. Box 30
Logan: National Mine Service Co., P. O. Box 1671

AMERICAN PULVERIZER CO.

1275 Macklind Ave., St. Louis, Mo.

DISTRIBUTORS

Georgia, Atlanta 3: J. B. Frescoln, 716 Walton Bldg.
Illinois, Chicago 5: Mayer & Oswald Inc. 417 S. Dearborn
Kentucky Louisville: Alfred Halliday Co., Inc., P.O. Box 756
Missouri, Kansas City 12: W. C. Carolan Co., 612 W. 47th St.
North Carolina, Charlotte 3: A. M. Stephenson, 1366 E. Morehead St.
New York, New York 17: Howard L. Hill, 101 Park Ave.
Ohio, Cincinnati 2: W. W. Baerbalck & Associates, 1427 Beaverton Ave.
Cleveland 3: A. Moore and Co., 3091 Mayfield Road
Pennsylvania, Cheltenham: C. B. McQuarry, Box 52
Pittsburgh 1: Titzel Engineering & Equipment Co., 260 42nd St.

AMERICAN STEEL & WIRE DIV. UNITED STATES STEEL CORP.

Rockefeller Bldg., Cleveland 13, Ohio

DISTRICT SALES OFFICE

Colorado, Denver: 1310 First Nat. Bank Bldg., AMherst 6-3001
Illinois, Chicago: 208 S. LaSalle St., CEntral 6-9200
Missouri, Kansas City: Power & Light Bldg., GRand 1-2050
St. Louis: 1221 Locust St., CEntral 1-1277
New York, New York: 71 Broadway, DIgby 4-9000
Ohio, Cincinnati: Fifth-Third Bank Bldg., Garfield 1-4460
Cleveland: Rockefeller Bldg., TOwer 1-2000
Pennsylvania, Philadelphia: Suburban Station Bldg, LO-4-4000
Pittsburgh: 525 William Penn Pl., EXpress 1-2345

DISTRIBUTORS

Alabama, Fairfield: Tennessee Coal & Iron Div., U.S.S., Phone State 5-8011
California, San Francisco: Columbia Geneva Steel Division, U.S.S., 120 Montgomery St., Sutter 1-2500
New York, New York: U.S.S. Export Co., 30 Church St., COrtlandt 7-7474

THE ATKINSON ARMATURE WORKS

Pittsburg, Kansas: The Atkinson Armature Works, 116 E. 1st St., Phone: 1754

AUSTIN POWDER CO.

Rockerfeller Bldg., Cleveland, Ohio, Main 1-0304

DISTRICT SALES OFFICES

Indiana, Evansville: P. O. Box 177
Kentucky, Madisonville:

SALES AGENTS

Illinois, Eldorado: Paul Horton, 2102 Main St., Bridge 3-4598
Indiana, Boonville: Perry A. Corn, 1203 S. 2nd St., P.O. Box 103, Phone 1029
Boonville: Jerry L. Downey, R. R. #5 Phone 196J3
Evansville: Edgar J. Becker, 2109 Vogel Rd., GR 6-1625
Evansville: Ben Hatley, 616 N. W. 2nd St., HA 4-8275
Evansville: Maurice L. Jones, 4600 Taylor Ave., GR 7-0662
Evansville: Clark Wilkinson, 1681 Taft Ave., GR 7-3802
Linton: Richard Jones, 510 G St., Phone 1381
Kentucky, Jackson: Gilbert Trail, Box 42, NO 6-2433
Henderson: James T. Eddins, 450 Crestview Dr., Valley 7-3425
Hodgenville: C. L. Hughes, P.O. Box 4, EL 8-3464
Madisonville: Edward Callaway, 447 W. Arch St., Taylor 1-2836
Madisonville: Thomas King, 804 Sunset Dr., Taylor 1-4566
Madisonville: Don Lyons, 458 Iola St., Taylor 1-3439
Madisonville: Lesle Todd Taylor 1-1816
Ohio, Bellare: V. W. Allen, P. O. Box 379, ME 3-9373
Columbus 14: A. A. Mellin, 119 Aldrich Rd., AM 2-7246
Mentor: Larry Strimple, R.D. 1, 315 Liberty St., BL 7-7494
Pennsylvania, Brookville: Ron Smith, P.O. Box 415 Phone 289
Philipsburg: George Humphrey, P.O. Box 96, DI 2-4874
Pittsburgh 27: Robert Chorpenning, 1334 Prospect Rd., TU 2-8423
Pittsburgh 36: 266 Constitution Dr., OL 5-7964
Six Mile Run: M. H. McMillin, PA 8-2703
Scranton: W. J. Raeder, 148 Adams Ave., DI 2-0169
Tennessee, LaFollette: Eugene Childs, P.O. Box 2, Phone 1342J
Memphis: J. W. Torrey, 88 E. McKellar St., EX 7-9641
Nashville: L. F. O'Donohoe, 219 Cherokkee Rd., CY 8-1872
Virginia, Grundy: C. S. Schubert, P.O. Box 175, WE 5-5221
Norton: J. M. Wilson, P.O. Box 40, Phone 105
West Virginia, Bradshaw: Hugh Edwards, Phone 4031
Charlestown: W. B. Craver, Jr., 933 Churchill Circle, DI 6-1663
Chapmanville: T. J. Wilding, P.O. Box 110, UL 5-4521
Masontown: A. De Prospero, Jr., UN 4-2181
Mt. Hope: Joseph Trail, P.O. Box 42, Phone 254
Welch: William Gergely, CH 8-3225

AUSTIN-WESTERN CONSTRUCTION EQUIPMENT DIV., BALDWIN-LIMA-HAMILTON CORP.

AURORA, Ill.

DISTRIBUTORS

Alabama, Birmingham 1: Joe Money Machinery Co., Inc., P.O. Box 1389, 903 Third Avenue West, State 8-6501
Chickasaw: May Machinery Co., Drawer R, Telegraph Road, Phone Mobile — HEmlock 3-9559
Arkansas, Fort Smith: R. A. Young & Son, Inc., 301 South Tenth St., SUnset 3-8901
Little Rock: R. A. Young & Son, Inc., 5th and Rector St., FRanklin 2-0172
Colorado, Denver 16: Macdonald Equipment Co., 5300 Colorado Blvd., AMherst 6-2641.
Georgia, Atlanta 18: R. S. Armstrong & Bro. Co., 676 Marietta St., N.W., JAckson 4-6434
Illinois, Rock Island: Midland Truck and Equipment, Inc., 2219 Third Ave., Phone 8-8235
Melrose Park: McAllister Equipment Co., 1615 N. Mannheim Rd., Phone Filmore 5-2740
Indiana, Indianapolis: Malotte Machinery Co., Inc., 6937 E. 42nd St., Phone Liberty 7-5453
Petersburg: Fred Malotte Machinery Co., Inc., P. O. Box 34, Main St., Phone 98
Iowa, Des Moines 9: Hawkeye Machinery Co., 1225 Walnut St., ATlantic 2-0244

Missouri, St. Louis 10: Machinery, Inc., 5081 Manchester Ave., Jefferson 5-2056
Montana, Butte: Hall-Perry Machinery Co., 812 E. Iron St., Phone 2-2323
North Carolina, Charlotte 1: H. B. Owsley & Son, Inc., P.O. Box 449, U.S. Highway 21 S., Franklin 6-8444
North Dakota, Fargo: Northwestern Equipment, Inc., 2800 West Main St., Phone 5-7583
Minot: Northwestern Equipment Co. of Minot, P.O. Box 152, U.S. Highway 52 West, Phone 69-111
Ohio, Cleveland 11: W. T. Walsh Equipment Co., 12750 Berea Rd., Clearwater 2-4660
Cleveland 30: Cleveland Contractors Equipment Co., 10904 Brookpark Rd., Shadyside 1-5570
Columbus 7: Columbus Equipment Co., 50 E. Kingston Ave., Hickory 3-6541
Columbus 22: Lorenz Equipment Co., 547 West Rich St., Capital 8-2647
Dayton 1: Flack Equipment Co., P. O. Box 953, 1240 McCook Ave, Phone Adams 8121
Toledo 4: Howard T. Moriarity Co., 137-143 Broadway, Phone Cherry 8-5538
Oklahoma, Enid: Bert Smith Road Machinery Co. Inc., P.O. Box 1266, 321 West Chestnut St., Adams 4-4950
Oregon, Portland 14: Columbia Equipment Co., 1240 S. E. 12th Ave., Belmont 2-7148
Pennsylvania, Carnegie: John W. Patterson Co., P.O. Box 515 128 Hanover St., Rook Station, Browning 9-3500
Erie: J. F. Brittain, Inc., R.D. 4, Phone 999-105
Harrisburg: Stephenson Equipment Inc., Box 69—Hill Station, 4200 Chambers Hill Road, Cedar 8-4220
Philadelphia 43, Stewart Equipment Co. of Phila., Inc., 52nd St. and Woodland Ave., Saratoga 7-1611
South Dakota, Sioux Falls: Pecaut Equipment Co., 900 E. Eighth St., Phone 8-6048
Tennessee, Knoxville: Peterson Machinery of Knoxville, Inc., 3115-3117 Central Ave., N. W., Phone 5-3572
Nashville 4: Peterson Machinery Co., 309 Seventh Ave. South, Phone Alpine 5-8608
Texas, Dallas 1: Hi-Way Machinery Co., 6312 Commerce St., Taylor 4-5168
Utah, Salt Lake City 15: Western Machinery Co., Box 2548, 2300 South Main St., Ingersol 6-8668
Virginia, Richmond 27: Capital Equipment Co., Inc., P.O. Box 9246—Bellevue Station, 2050 Westmoreland St., Phone 5-1789
Washington, Seattle: Columbia Equipment Co., 5030 First Ave., South, Lander 1530
Spokane: Columbia Equipment Co., North 1007 Freya St., Keystone 4-1581
West Virginia, Huntington 3: Porter Supply Co., Inc., P.O. Box 736, 1703 Seventh Ave., Phone 2-6651
Wyoming, Cheyenne: Keremi Tractor and Equipment Co., 703 W. Seventeenth St., Phone 8-8923

B

BIN-DICATOR CO.

13946 Kercheval St., Detroit 15, Mich.

BOWDIL CO., THE

Boylan Ave. S.E., Canton 7, Ohio, Glendale 6-7176

DISTRICT SALES OFFICES

Colorado, Denver: Wm. Radcliff, 761 Steele St., Phone EA 2-7151
Illinois, West Frankfort: Randal A. Leach, 1004 E. St. Louis St., Phone 675
Ohio, Magnolia: C. W. Weisburn, Phone UN 6-2166
Pennsylvania, Perryopolis: J. M. Blasco, North Liberty Ave., Phone Redfield 6-2575
Kentucky, Whitesburg: A. J. Leach, Sand Lick Rd., Phone 2232
West Virginia, Danville: E. D. Caudill, Box 132. Phone 810
Utah, Helper: V. L. Walkington, Phone 144
Canada, Drumheller, Alberta: Western Distributors Co.

C

CENTRIFUGAL & MECHANICAL INDUSTRIES, INC.

146 President St., St. Louis 18, Mo., PR 6-2848

DISTRICT SALES OFFICE

West Virginia, Huntington: 925-6th Ave., Huntington 4-4131

CHEATHAM ELECTRIC SWITCHING DEVICE CO.

4780 Crittenden Dr., Louisville 9, Ky., Emerson 3-3571

SALES OFFICES

Utah, Salt Lake City: 375 South West Temple DA 2-4311

CINCINNATI MINE MACHINERY CO., THE

Cincinnati 25, Ohio

DISTRIBUTORS

Alabama, Birmingham: J. T. Sudduth & Co., P.O. Box 3123 Avondale Station
Colorado, Denver: Union Supply Co., P.O. Box 6735 Stockyard Station
Illinois, Benton: W. M. Hales Co., Box 303
Chicago: W. M. Hales Co., 605 W. 116th St.
Danville: W. M. Hales Co., Box 65
Hillsboro: W. M. Hales Co., Box 356
West Frankfort: W. M. Hales Co., Box 239
Kentucky, Harlan: McComb Supply Co.
Madisonville: W. M. Hales Co., Box 91
Pennsylvania, Johnstown: Penn Machine Co., Station St.
Pittsburgh: Penn Machine Co., Union Trust Bldg.
Tennessee, Jellico: McComb Supply Co.
Utah, Helper: Carbon Transfer & Supply Co., P.O. Box 180
Kenilworth: Frank Armstrong
West Virginia, Huntington: Huntington Supply & Equipment Co., Box 370
Canada, Alberta, Drumheller: Gorman's Ltd.
Alberta, Edmonton: Gorman's Ltd.
New Brunswick, St. John: E. S. Stephenson & Co., 15 Dock St.
Nova Scotia, Halifax: E. S. Stephenson & Co., P.O. Box 1033
Chile, Santiago: Sociedad Importadora del Pacifico Ltda., Alameda 1166, Casilla 82-D
South Africa, Durban: F. G. Licence (Pty) Ltd., P.O. Box 1362

COLLYER INSULATED WIRE CO.

245 Roosevelt Ave. Pawtucket, R.I.

COMBUSTION ENGINEERING INC., RAYMOND DIV.

1315 N. Branch St., Chicago 22, Ill.

DISTRICT SALES OFFICES

North Carolina, Charlotte 3: 518 E. Morehead St.
Ohio, Cincinnati 2: 1101 Enquirer Bldg.
Cleveland 13: 733 The Illuminating Bldg.
Pennsylvania, Philadelphia 3: 1616 Walnut St.
Pittsburgh 22: 1 Gateway Center

COMPTON, INC.

P.O. Box 1946, Clarksburg, W. Va.

CRESCENT BELT FASTENER CO.

381 Fourth Ave., New York 16, N. Y.

DISTRIBUTORS

Kentucky, Louisville: Belknap Hardware & Mfg. Co., 111 East Main St.
Louisville: Neill-La Vielle Supply Co., 2211 South Brook St.
Paducah: Henry A. Petter Supply Co.
Ohio, Canton: Canton Hardware Co., 1221 Third St. N.E.
Canton: Canton Supply Co., 938 Cleveland Ave., S.W.
Cincinnati: E. A. Kinsey Co., 327 West 4th St.
Cincinnati: Queen City Supply Co., Pearl & Elm St.
Cleveland: W. Bingham Co., 1278 West Ninth St.
Cleveland: The Cleveland Oak Belting Co., 2915 Detroit Ave.
Cleveland: The W. M. Pattison Supply Co., 777 Rockwell Ave.
Youngstown: Cavanaugh Company, 928 West Rayon Ave.
Youngstown: Stambaugh Supply Division 102 East Commerce St.
Pennsylvania, Altoona: Pittsburgh Gage & Supply Co., 2701 Beale St.
Erie: H. P. Weller Supply Co.
Pittsburgh: Frick & Lindsay Co., Sandusky & Robinson Sts., N. S.
Pittsburgh: Pittsburgh Gage & Supply Co., 3000 Liberty Ave.
Pittsburgh: C. A. Turner, Inc., 117 Third Ave.
Sharon: Pittsburgh Gage & Supply Co.
Titusville: Pittsburgh Gage & Supply Co., 421 South Perry St.
Tennessee, Chattanooga: Chattanooga Belting & Supply Co., 1221 Market St.
Knoxville: Tidewater Supply Supply Co., Inc., 1506 Island Home Ave.
West Virginia, Charleston: Industrial Rubber Products Co., 815 Court St.
Huntington: Banks-Miller Supply Co., 330 Third Ave.

D

DANIELS CO., THE, CONTRACTORS, INC.

22 N. 5th St., Indiana, Pa. Hopkins 3-3559 & 3-3550

DISTRICT SALES OFFICES

New Jersey, Newark
West Virginia, Bluefield

DAVEY COMPRESSOR CO.

600 Franklin Ave., Kent, Ohio

DISTRICT SALES OFFICES

Georgia, Decatur: 2812 Laurel Ridge Dr., Melrose 4-7714
New Jersey, Ridgewood: 553 Hillcrest Rd., Gilbert 5-3120
Ohio, Cuyahoga Falls: 2785 Tift St., Walbridge 8-9539

DISTRIBUTORS

Alabama, Adamsville: Blackwell Trucking Co., P.O. Box 3, State 8-0119
Birmingham: Money Machinery Co., 903 3rd Ave., W., Telephone: 58-6501
Kentucky, Lexington: Contractors Equipment Co., Inc., 780 E. 3rd. St., Telephone 2-1475
Louisville: Contractors Equipment Co., Inc., 4410 Poplar Level Rd., GL 8-3022
Ohio, Columbus 22: Machinery & Tool Rentals, Inc., 511 West Town St., Capital 8-6725
Pennsylvania, Forty Fort: Yarrish Equipment Co., 1609 Wyoming Ave.
Frostburg: Stackdale Mine Supply Co., Punxsutawnwy 2182
Pittsburgh 21: Conte Equipment Co., P.O. Box 8607 Brandywine 1-4380
West Virginia, Charlestown 27: Baker Equipment Engr. Co., Inc., 404 Morris St. Telephone: 2-0178

Continued

Charlestown: Equipment Distributors, Ind., P.O. Box 4275
Vienna: Vienna Tractor & Equipment Corp., 1016 18th St.

DENVER EQUIPMENT CO.

1400 17th St., Denver 17, Colo., Cherry 4-4466

DISTRICT SALES OFFICES

Colorado, Colordo Springs: 500 S. Sewatch St., Melrose 3-7158
New York, New York: Empire State Bldg., Chickering 4-6510
Canada, British Columbia, Vancouver: Credit Foncier Bldg., Mutual 3-7595
Ontario, Toronto: 185 Bay St., Empire 3-8836

DRAVO CORP.

Neville Island, Pittsburgh 25, Pa.

DUFF-NORTON CO.

2709 Preble Ave., Pittsburgh 30, Pa.

E

ENTERPRISE WHEEL & CAR CORP.

Bristol, Va.

DISTRICT SALES OFFICES

West Virginia, Huntington: Camden Rd., Phone 20343
Bluefield: P.O. Box 182, Davenport 7-6640

DISTRIBUTOR

Alabama, Homewood: L. D. Brooks, P.O. Box 5725, Tremont 1-7418

EXIDE INDUSTRIAL DIV., ELECTRIC STORAGE BATTERY CO.

42 S. 15th St., Philadelphia 2, Pa.

DISTRICT SALES OFFICES

Alabama, Birmingham 9: 1925 29th Ave. S., Tremont 9-5321
Colorado, Denver 2: 234 Commonwealth Bldg., Main 3-7793
District of Columbia, Washington 6: 1819 "L" St., N.W., National 8-0800
Georgia, Atlanta 10: 1246 Allene Ave. S.W., Plaza 8-2621
Illinois, Chicago 9: 5335 S. Western Blvd., Walbrook 5-9800
Peoria: 423 1st Nat'l Bank Bldg., Phone 4-5051
Indiana, Indianapolis 4: 325 Bankers Trust Bldg., Melrose 5-6727
Missouri, Kansas City 23: 129 S. Belmont Blvd., Benton 1-6300
St. Louis 8: 3928 Lindell Blvd., Olive 2-1310
New York, New York 36: 25 W. 43d St., Bryant 9-8100
North Carolina, Charlotte 6: 106 N. Caldwell St., Franklin 5-7966
Ohio, Cincinnati: Rm. 426, 307 E. 4th St., Main 1435
Cleveland 14: 1014 Engineers Bldg., Cherry 1-6231
Oregon, Portland 5: 1224 S.W. Morrison St., Capital 2-3778
Pennsylvania, Kingston: 33 Popular St., Butler 7-8294
Philadelphia 4: 101 N. 33d St., Evergreen 2-5858
Pittsburgh 16: 1608 Potomac Ave., Fieldbrook 1-2832
Tennessee, Memphis: 902 Dermon Bldg., Jackson 6-5842
Texas, Dallas 1: 2133 McKinney Ave., Riverside 1-9977
Utah, Salt Lake City 7: P.O. Box 133, Murray Branch, Elgin 9-5766
Washington, Seattle 1: 500 Wall St., Main 3-1377
Spokane 1: 617 Paulsen Bldg., Madison 4-1295
West Virginia, Charleston: P.O. Box 1562, Dickens 6-8201

F

FAIRMONT MACHINERY CO.

Fairmont, West Virginia, Fairmont 1672

FALK CORP., THE

Milwaukee, Wis.

DISTRICT SALES OFFICES

Alabama, Birmingham 3: Brown-Marx Bldg., Room 649, Phone 54-1433
Illinois, Chicago 3: 105 W. Adams St., STate 2-6686
Peoria: 800 S. Adams St., Phone 6-0433
Indiana, Indianapolis 5: 2132 E. Illinois Ave., Clifford 5-5434
Maryland, Baltimore 12: 4231 Greenmount Ave., Tuxedo 9-4969
Missouri, St. Louis 5: 8029 Forsyth Blvd., Parkview 5-8300
Kansas City 8: (B. L. McCreary & Son) 1819 Central St. Harrison 1-1668
New Jersey, Newark 2: 100-102 Parkhurst St., Bigelow 2-5300
Ohio, Akron 9: (B. W. Rogers Co.,) 850 S. High St., Hemlock 4-4181
Cincinnati 2: 609 American Bldg., Main 1-2364
Cleveland 15: Room 215 2036 E. 22nd St., Main 1-0074
Dayton 2: 410 W. 1st St., Baldwin 4-4833
Pennsylvania, Pittsburgh 19: 410 Grant Bldg., Atlantic 1-1139
Upper Darby: 205 Long Lane, Flanders 2-5014
Tennessee, Knoxville 17: (Bowditch & Co.), 1311-C N. Broadway, Phone 4-2513
Virginia, Richmond 19: (Williamson & Wilmer), 617 Mutual Bldg., Phone 3-9003
West Virginia, Charleston 2: 3145 Washington St. W., Riverside 4-1821
Fairmont: 801 Coleman Ave., Phone 3453

FEMCO, INC.

Irwin, Pa.

DISTRIBUTORS

Alabama, Birmingham: National Mine Service Co.
Kentucky, Ashland: National Mine Service Co.
Jenkins: National Mine Service Co.
Madisonville: National Mine Service Co.
Pennsylvania, Forty Fort: National Mine Service Co.
Indiana: National Mine Service Co.
Pittsburgh: National Mine Service Co., 564 Alcoa Bldg
Utah, Salt Lake City: Industrial Physics & Electronics Co.
West Virginia, Beckley: National Mine Service Co.
Logan: National Mine Service Co.
Morgantown: National Mine Service Co.

FLOOD CITY BRASS & ELECTRIC CO.

Messenger & Elder Streets, Johnstown, Pa., Phone 8-1281

SALES AGENTS

Alabama, Birmingham 1: Salmon & Company Inc., P.O. Box 2388
West Virginia, Charleston 31: Kanawha Rail & Machinery Corp. P.O. Box 3069 Walnut 5-1191

FRED'S WELDING SERVICE
P. O. Box 178, Grundy, Virginia, Phone: 2722

FUEL PROCESS CO.

900 D St., South Charleston, W. Va.

G

GUNDLACH MACHINE CO., T. J., DIV. OF J. M. J. INDUSTRIES

226 Centreville Ave., Belleville, Ill., Adams 3-7208

SALES AGENTS

Colorado, Denver: Clyde E. Clarkson, 4831 E. Harvard Lane, Skyline 6-5277
Illinois, Chicago: Schonthal & Associates, Suite 309, 224 S. Michigan Ave., Wabash 2-8350
Pennsylvania, Greensburg: Andrew M. Gardner, 626 Park Lane, Phone 3350
Philadelphia: A. R. Amos Co., 713 Commercial Trust Building, Rittenhouse 6-3675
West Virginia, Huntington 1: Marshall Equipment Co., Box 1367, Phone 3-8691
Wheeling: Richard M. Wilson, 27 Oak Park, Woodale 586

H

H & L TOOTH COMPANY

1540 South Greenwood Avenue, Montebello, Calif.

DISTRIBUTORS

Alabama, Birmingham: Leary & Owens Machinery Co., 3600 5th Ave. N.
Montgomery: Leary & Owens Machinery Co., 3165 Mobile Rd.
Colorado, Denver: Air Rentals, Inc., 3301 Walnut St.
Aurora: M. J. Crose Mfg. Co., Inc., 15225 E. Colfax Ave.
Illinois, Salem: John Fabick Tractor Co.
Marion: John Fabick Tractor Co.
Indiana, Evansville: Reid-Holcomb Co., Inc., Boonville Rd. East
Indianapolis: Reid-Holcomb Co., Inc., 1815 Kentucky Ave.
South Bend: Reid-Holcomb Co., Inc., West Ireland St.
Kentucky, Louisville: Williams Tractor Co., 3800 Crittenden Dr.
Paducah: Williams Tractor Co., 8th & Burnett Sts.
Missouri, Kansas City: Buchanan Equipment Co., 2645 Southwest Blvd.
St. Louis: J. Fabick Tractor Co., 3100 Gravos Ave.
Sikeston: J. Fabick Tractor Co.
Ohio, Cincinnati: Carroll & Edwards Co., Richmond & McLean Sts.
Cleveland: W. T. Walsh Equipment Co., 12750 Berea Road
Columbus: Capitol Road Machinery Co., 945 West 3rd Ave.
Pennsylvania, Harrisburg: Furnival Machinery Co., 5105 Paxton St.
Pittsburgh: Atlas Equipment Corp., 635 Ridge Ave.
Tennessee, Chattanooga: Power Equipment Co., 1080 Duncan Ave.
Memphis: Tri-State Equipment Co., 520 Mulberry Ave.
Nashville: Power Equipment Co., 800 6th Ave. N.
Utah, Salt Lake City: Heiner Equipment Co., 501 W. 7th South
Virginia, Roanoke: J. W. Burress, 1701 Shenandoah Ave., N. W.
West Virginia, Charlestown: West Virginia Tractor & Equipment Co.
Clarksburg: West Virginia Tractor & Equipment Co., 100 Wood St.

HARNISCHFEGER CORP., CONSTRUCTION & MINING DIV.
4400 Nat'l Ave., Milwaukee 14, Wis.

HAUSER-STANDER TANK CO.

Cincinnati 32, Ohio

HENDRICK MANUFACTURING CO.

Carbondale, Pa.

DISTRICT SALES OFFICES

New York, New York 7: 30 Church St.
Pennsylvania, Hazleton: Box 315
Pittsburgh 8: 6802 Frankstown Ave.

SALES AGENTS

Illinois, Chicago 4: Warren F. Kendrick, 224 S. Michigan Ave.

Ohio, Cleveland: T. E. Sullenger, Westlake Hotel
Louisville: Contractors Equip-
Engineering Co. of Ill.,
DISTRICT SALES OFFICES

Missouri, St. Louis: Crandall Ricker Sales Corp., 1169 Paul Brown Bldg.
Pennsylvania, Philadelphia: The Benson, Suite 112-c, Washington Lane & Township Line, Jenkintown, Pa.
Ohio, Cleveland 21: Arthur C. Baker, 4062 Mayfield Rd.
West Virginia Huntington: J. Y. Smythe, 832 Eleventh Ave.

HERCULES POWDER CO.,
900 Market St., Wilmington 99, Del.

DISTRICT SALES OFFICES
Alabama, Birmingham 3: First National Building, 17 N. 20th St.
California, Los Angeles 5: 3460 Wilshire Blvd.
San Francisco 4: 120 Montgomery St.
Illinois, Chicago 4: McCormick Bldg., 332 S. Michigan Ave.
Minnesota, Duluth 2: Torrey Bldg., 314-16 W. Superior St.
Missouri, Joplin: First National Bank Bldg., 404 Main St.
New York, New York 17, 380 Madison
Pennsylvania, Pittsburgh 22: 2 Gateway Circle, 603 Stanwix St.
Utah, Salt Lake City 1: Kearns Bldg., 136 S. Main St.

HEWITT-ROBINS, INCORPORATED
Stamford Conn.

DISTRICT SALES OFFICES
Alabama, Birmingham: 3118 Third Ave., So., Fairfax 2-8765
Arizona, Phoenix: 207-B Camelback Rd., Crestwood 4-0245
Colorado, Denver: 660 Bannock St., Acoma 2-8484
Illinois, Chicago: 402 West Randolph St., Dearborn 2-4570
Indiana, Indianapolis: 2813 Questend, S. Dr., Walnut 4-0577
Kentucky, Louisville: 319 Foeburn Lane, Twinbrook 7-2978
Missouri, St. Louis: 4030 Chouteau Ave., Jefferson 5-8240
New York, New York: 370 Lexington Ave., Murray Hill 6-2400
North Carolina, Charlotte: 3601 Hutchinson Ave., Franklin 7-2571
Ohio, Cleveland: 314 Superior Ave., N.E. Superior 1-8020
Pennsylvania, Ft. Washington: Ft. Washington Industrial Park, Mitchell 6-3900
Pittsburgh: 951-952 Union Trust Bldg., Atlantic 1-5548
Utah, Salt Lake City: 458 So. Third St. E., Davis 2-1144
West Virginia, Bluefield: 1417 College Ave., Davenport 5-6277
Charleston: 4000-B McCorkle Ave. SE, Walnut 5-4211
Fairmont: 196 Broadview Ave., Fairmont 4883

HEYL & PATTERSON, INC.
55 Fort Pit Blvd. Pittsburgh 22 Pa.

DISTRIBUTORS
Indiana, Terre Haute: Templeton-Matthews Corp., 905 Sycamore Bldg.
West Virginia, Charleston 26: Kanawha Manufacturing Co., 1520 Dixie St.

HUBER-WARCO CO.
Marion, Ohio

DISTRIBUTORS
Illinois, Chicago 29: Gil Boers Equipment Co., 7625 South Kedzie Ave.
Kentucky, Louisville 17: Emmett C. Watson Co., 310 E. Brandeis St.
Missouri, St. Louis 24: Cummings, McGowan & West, Inc., 9100 Olive Street Rd.
Ohio, Cadiz: W. W. Williams Co., 700 Lincoln Ave.
Columbus 8: W. W. Williams Co., 835 W. Goodale Blvd.
Pennsylvania, Hazleton: W. N. Dippel, Inc., Route 924, Box 313
Pittsburgh 6: Brinker Supply Co., 6545 Hamilton Ave.
Tennessee, Knoxville: Story Brothers, Inc., 4130 Clinton Highway
Nashville: McCarthy, Jones & Woodard, 723 Argyle Ave.
West Virginia, Charleston: Equipment Distributors, Inc 5528 MacCorkle Ave. S.E.

I

INGERSOLL RAND CO.
11 Broadway, New York 4, N. Y.

DISTRICT SALES OFFICES
Alabama, Birmingham 3: 1700 3d Ave., South, Fairfax 3-2576
Colorado, Denver 2: 1641 Blake St., Keystone 4-2245
Illinois, Chicago 6: 400 W. Madison St., Dearborn 2-4626-35
Missouri, St. Louis 3: 2327 Locust Blvd., Garfield 1-0888
New York, Buffalo 2: 117 W. Chippewa St., Cleveland 6437-8-9-40
New York 4: 11 Broadway, Digby 4-6070
Ohio, Cincinnati 6: 428 McGregor Ave., Plaza 1-8060
Cleveland 3: 4506 Chester Ave., Express 1-9889
Pennsylvania, Philadelphia 3: 2037 Chestnut St., Locust 7-7535
Pittsburgh 22: 932 Penn Ave., Atlantic 1-9070-1-2-3
Scranton 9: 315 Walnut St., Diamond 2-8121
Tennessee, Knoxville 24: 412 W. Jackson Ave., Phone 3-3145-6-7
Utah, Salt Lake City 1: 144 S. W. Temple St., Davis 8-8127
Virginia, Richmond 21: 3431 W. Leigh St., Phone 5-2861

J

JOY MANUFACTURING CO.
Henry W. Oliver Bldg., Pittsburgh 22, Pa.

DISTRICT SALES OFFICES
Colorado, Denver 2: 1626 Wazee St., Keystone 4-6334
District of Columbia, Washington 6: 1741 K. St., N.W., Executive 3-6200
Illinois, Centralia: 5th & Chestnut Phone 4707
Chicago 6: 560 W. Washington Blvd., Dearborn 2-4670
Missouri, St. Louis 10: 1203 Macklind Ave., Mission 5-6670
Montana, Butte: 24 W. Granite St., Phone 6721
New York, New York 6: 140 Cedar St., Cortlandt 7-6545
Ohio, Cleveland 35: 16141 Puritas Ave., Clearwater 1-9444
Oregon, Portland 9: 1631 N.W. Thurman St., Capital 7-5561
Pennsylvania, Luzerne: 453 Main St., Butler 8-4523
Philadelphia 2: 1420 Walnut St., Pennypacker 5-1414
Pittsburgh 16: 3021 Banksville Rd., Locust 3-4000
Tennessee, Knoxville 2: 108 W. Main St., Phone 2-4121
Texas, Dallas 20: 7425 Hines Blvd., Fleetwood 7-3949
Utah, Salt Lake City 4: 998 S. Sixth West St., Davis 2-0481
Washington, Seattle 1: 2411 Western Ave., Mutual 2266
West Virginia, Fairmont: P.O. Box 1045, Phone 1740
Huntington: 742 8th Ave., Phone 3-3439

DISTRIBUTORS
Alabama, Birmingham: Crandall Engineering Co., 601 N. 10th St., Alpine 1-9262
Colorado, Denver 2: Schloss & Shubart, 1626 Wazee St., Acoma 2-2741

K

KENNAMETAL INC., MINING TOOL DIV.
Bedford, Pa., Phone 755

DISTRICT SALES OFFICES
Illinois, Benton: 1307 N. Main St., Phone 8-8811
Indiana, Vincennes: 224 Wilbur St., Phone 3299
Kentucky, Barbourville: 419 S. Main St., Box 337, Phone 321
Belfry: Box 28, Phone Stone 3917
Ohio, Crooksville: 303 Walnut St., Phone 410-S
Pennsylvania, Cadogan: Phone Roger 2-9964
Glenshaw: 107 Orchard Ave., Hunter 6-5722
Latrobe: 215 Loyalhanna Ave., Keystone 7-4333
Mars: Box 236, National 5-9011
Rimersburg: Box No. 289 Phone 113
Waynesburg: Morning Side, RD No. 3, Phone 1214Y (Orval Robson) Phone 1076
Wyoming: 41 Shulde Lane, Phone Wyoming 49
Tennessee, Chattanooga 11: 1314 S. Seminole Dr., Phone Oxford 8-3021
Utah, Springville: 164 W. 2 S., Hunter 9-5541
West Virginia, Bluefield: Box No. 834, Davenport 7-8376
Morgantown: P.O. Box 1133, Phone 9503
Oak Hill: 368 Kelly Ave., Phone 938

DISTRIBUTORS
Alabama, Birmingham: Salmon & Co., Inc.
Illinois, Chicago 4: Vanguard Equipment & Supply Co.
Kentucky, Jenkins: National Mine Service Co.
Madisonville: National Mine Service Co.
Michigan, Ishpeming: Burridge-Nyland Equipment Company
New Mexico, Carlsbad: Bit Grinding Service Inc.
Pennsylvania, Forty-Fort: National Mine Service Co.
Indiana: National Mine Service Co.
Latrobe: McGinnis Bros. Bit Service Inc.
Washington: Fairmont Supply Co.
Virginia, Andover: Central Supply Service of Virginia, Inc.
McClure: Erwin Supply & Hardware Co.
West Virginia, Beckley: National Mine Service Co.
Cowen: Pennsylvania & West Virginia Supply Corp.
Fairmont: Fairmont Supply Co.
Logan: National Mine Service Co.
Morgantown: National Mine Service Co.
Pennsylvania & West Virginia Supply Corp.
Shinnston: Erwin Supply Co.
Triadelphia: Pennsylvania & West Virginia Supply Corp.

KENSINGTON STEEL, DIVISION OF POOR & CO.
505 E. Kensington Ave., Chicago 28, Ill.

KOPPERS COMPANY, INC., WOOD PRESERVING DIV.
750 Koppers Bldg., Pittsburgh 19, Pa., Express 1-3300

DISTRICT SALES OFFICES
Alabama, Montgomery: P.O. Box 510 Amherst 3-3416
Ohio, Marietta: 102 Front St., Phone Frontier 3-6437
Pennsylvania, Haverford: P.O. Box 389, 355-E, Lancaster Ave., Midway 2-5854
Pittsburgh: Peoples First National Bank Bldg., Smithfield & 7th Streets Express 1-3300

KW-DART TRUCK CO.
Kansas City 8, Mo., HA 6170

FACTORY SALES OFFICES
New York, Long Beach: John C. Morley, 23 Virginia Ave.
Continued

Morgantown: Mountainer Div of National Mine Service
Scranton 10: 530 Clay Ave., Diamond 6-3062
ment Co., P. O. Box 2858, 285 East Calhoun Street,
MYERS-WHALEY CO.

Ohio, Cleveland: T. E. Sullenger, Westlake Hotel
Utah, Bountiful: Mark T. Kasper, 944 East Center St.

DISTRIBUTORS

Alabama, Birmingham: Leary & Owens Machine Co., 3600 5th Ave.
Montgomery: Leary & Owens Equipment Co., 3165 Mobile Rd.
Georgia, Atlanta: W. C. Kaye & Co., Inc., 787 Windsor St. S.W.
Illinois, Oaklawn: Tractor & Equipment Co., 10000 S. Ridgeland Ave.
Indiana, Indianapolis: Seastrom & Co., Inc., 2357 Kentucky Ave.
Missouri, Kansas City: Funkhouser Equipment Co., 2425 Jefferson St.
North Carolina, Winston-Salem: J. W. Burress, 100 Waughtown St.
Ohio, Cleveland: Cleveland Contractors Equipment Co., 10904 Brookpark Rd.
Oregon, Portland 14: Balzer Machinery Co., 2136 S.E. 8th Ave.
Pennsylvania, Philadelphia 39: Constructors Equipment Corp., 345 N. 57th St.
Lancaster: Box 1118
Pittsburgh 29: Watson Eqpt. Co., P.O. Box 9707
Tennessee, Nashville: McCarthy-Jones & Woodard, 723 Argyle Ave.
Texas, Dallas 19: Lumby Machine Co., 6541 Forest Park Rd. at Mockingbird Lane
Utah, Salt Lake City 10: Arnold Machinery Co., Inc., P.O. Box 2220
Virginia, Roanoke: Southern Machinery Co., 2745 Shenandoah Ave. N.
West Virginia, Charleston: West Virginia Tractor & Equipment, P.O. Box 473

L

LEMAN MACHINE CO.

Post Office Box 236 Portage, Pa.

LeTOURNEAU-WESTINGHOUSE CO. WESTINGHOUSE AIR BRAKE DIV.

Peoria, Illinois

DISTRIBUTORS

Alabama, Birmingham: G. C. Phillips Tractor Co., Inc. P.O. Box 2897, Woodlawn Stat., 4419 1st Ave., N., Worth 1-4605
Colorado, Denver: Tudor Equipment Co., 6198 Colorado Blvd., Atlas 8-1513
Illinois, Marion: John Sutton Supply Co., P.O. Box 368 Phone 2-025
Indiana, Indianapolis: Miller Machinery, Inc., 7255 W. Washington St., P.O. Box 5785, Chappel 1-2511
Kentucky, Lexington: Contractors Equipment Co., Inc., 780 E. 3rd St., Phone 2-1475
Louisville: Contractors Equipment Co., Inc., 4410 Poplar Level Rd., Glendale 8-3022
Montana, Billings: Western Const. Equipment Co., 505 N. 24th St., P.O. Box 2537, Phone 9-5501
Missouri, Kansas City: Victor L. Phillips Co., 1600 Baltimore Ave., Harrison 1-0722
St. Louis 10: O. B. Avery Co., Inc., 1325 Macklind Ave., Mission 5-1810
Ohio, Cleveland 30: Cleveland Contr. Equip. Co., 10904 Brookpark Rd., Shadyside 1-5570
Columbus 7: 50 E. Kingston Ave., Hickory 3-6541
Oklahoma, Tulsa: Wylie-Stewart Mach. Co., Inc., P.O. Box 3216 Whittier Stat., 2443 Dawson Rd., Webster 9-5439
Pennsylvania, Butler: Wash Equipment Co., 208 S. Chestnut St., Butler 7-4996
Harrisburg: Furnival Machinery Co., 5101 Paxton St., P.O. Box 786, Cedar 8-1781
New Philadelphia: Furnival Machinery Co., Water St., P.O. Box 553, Market 2-8020
Philadelphia 31: Furnival Machinery Co., Lancaster Ave. at 54th St., Trinity 7-5200
Pittsburgh 23: A. T. Green Mach. Co., P.O. Box 9538, Sterling 1-9600
Tennessee, Chattanooga 1: Nixon Machinery & Supply Co., Inc., 1300 Carter St., P.O. Box 149, AM 7-5573
Knoxville: Nixon Machinery & Supply Co., Inc., 4717 Clinton Highway, P.O. Box 3034, Mutual 7-1601
Memphis: Tri-State Equipment Co., Inc., 520 Mulberry St., P.O. Box 2681, Jackson 5-3716
Nashville: Nixon Machinery & Supply Co., Inc., 1211 Demonbreun St., P.O. Box 176
Utah, Salt Lake City: Rocky Mt. Machinery Co., 1485 S. 2nd West St., P.O. Box 2037, Hunter 4-4378
Virginia, Lynchburg: Richmond Machinery & Equip. Co., Inc., P.O. Box 1278, 3742 Campbell Ave., Phone 7-2737
West Virginia, Charleston 22: W. Virginia Tractor & Equip. Co., P.O. Box 473, 1701 5th Ave., DI 6-5301
Clarksburg: W. Virginia Tractor & Equip. Co., P.O. Box 587, 100 Wood St., MA 4-7511

LINATEX CORP. OF AMERICA

P.O. Drawer "D" Stafford Springs, Conn.; or Wilkins Linatex, Ltd., 1975 Bois Franc Rd., St. Laurent, Quebec, Canada

Pennsylvania, Pittsburgh 19: S.E. Gane Co., 508 Grant St.

LINCOLN ENGINEERING CO., DIV. of the McNEILL MACHINE & ENGINEERING CO.

St. Louis 20, Mo.

FACTORY SALES OFFICES

Illinois, Chicago 16: Lincoln Engineering Co. of Ill., 2415 South Michigan Ave., CA 5-6022
Ohio, Cleveland 3: Lincoln Lubricating Systems, Inc., 4500 Euclid Ave., Express 1-4334
Oregon, Portland 14: Lincoln Engineering Co. of Calif., 1018 S.E. 8th Ave., Belmont 4-7469
Pennsylvania, Philadelphia 3: Lincoln Engineering Co., Div. of the McNeil Machine and Engr. Co., 1609 Vine St., Rittenhouse 6-8131
Pittsburgh: Lincoln Engineering Co., Div. of the McNeil Machine and Engr. Co., 134-36 South Whitfield, Montrose 1-1444
Texas, Ft. Worth 7: Fritz Keller, P.O. Box 9008, Sunset 5451
Canada, Toronto 2-B, Ontario: Lincoln Engineering Co. (Canada) Ltd., 81 John St., Empire 4-8040

LINK-BELT COMPANY

Dept. CAMGL-58, Prudential Plaza, Chicago 1, Ill.

DISTRICT SALES OFFICES

Alabama, Birmingham 9: 321 Oxmoor Rd., Tremont 1-1101
Colorado, Denver: Schloss & Shubart, 1626 Wazee St., Acoma 2-2741
Illinois, Chicago 9: 301 W. Pershing Rd., Atlantic 5-4401
Indiana, Indianapolis 6: 220 S. Belmont Ave., Melrose 2-5411
Kentucky, Louisville 8: 235 E. Burnett Street, Melrose 7-3668
Michigan, Detroit 4: 5938 Lindsdale Ave., Tyler 4-1100
Missouri, Kansas City 8: 2630 Holmes Street, Victor 2-9234
St. Louis 1: 317 N. 11th Street, Chestnut 1-1777
Ohio, Cleveland 20: 3592 Lee Road, Wyoming 1-0380
Pennsylvania, Pittsburgh 13: 5020 Centre Avenue, Museum 1-0600
Washington, Seattle 4: 3405 Sixth Avenue, S. Seneca 8200
West Virginia, Huntington 1: 1009 Fifth Ave., P.O. Box 510, Phone 3-9401
Australia, Marrickville (Sidney): Rich St., P.O. Box 41
Brazil, Sao Paulo: Rua Barao de Utapetininga 46
Canada, Scarboro Toronto 13 Ont.: 1960 Eglinton Ave., P.O. Box 173 Station H, Plymouth 5-4141
South Africa, Springs: P.O. Box 287, Industry Rd., New Era Springs, Phone 56-4136

THE LONG CO.

P.O. Box 331, Oak Hill, West Va., Phone 1191

SALES AGENTS

Alabama, Birmingham 5: J. L. Thomas, 429 S. 24th St.

LUDLOW-SAYLOR WIRE CLOTH CO.

634 S. Newstead Ave., St. Louis 10, Mo., Franklin 1-0636

DISTRICT SALES OFFICES

Alabama, Birmingham: 1727 6th Ave. N., Alpine 2-5151
California, Los Angeles 65: (Star Wire Screen & Iron Works, Inc., 2515 San Fernando Rd., Capitol 5-4101
Colorado, Denver: 1530 Carr St., Belmont 3-5421
Illinois, Chicago: 5807 W. Diversey Ave., National 2-1147
Pennsylvania, Pittsburgh: Union Trust Bldg., Atlantic 1-2262
Texas, Houston: 5638 Harvey Wilson Drive, Walnut 1-0291

M

MANITOWOC ENGINEERING CORP.

S. 16th St., Manitowoc, Wis., Murray 4-6621

DISTRIBUTORS

California, San Francisco 24: Fred E. Barnett Co., 1455 Custer Ave., Mission 8-2970
Indiana, Evansville 14: Manitowoc Eng. Corp., 1222 Lincoln Ave., Harrison 30398
Iowa, Cedar Rapids: Moorman Equipment Co., 3028 Mt. Vernon Rd., S.E., Empire 3-2047
Kentucky, Madisonville: Hart Equipment Co., 122 E. Center, TA 1-4645
Ohio, Columbus 8: W. W. Williams Co., The, 835 W. Goodale Blvd., Capital 8-6651
Pennsylvania, Bridgeville: Anderson Equipment Co., P. O. Box 427, Lehigh 1-6020 or Bridgeville 262

MANNING CO., CHARLES E.

4700 Clairton Blvd., Pittsburgh 36, Pa. Tuxedo 2-0800

DISTRICT SALES OFFICES

Pennsylvania, Pittsburgh 19: National Mine Service Co., Alcoa Bldg., CO 1-0226
Pittsburgh: Pittsburgh Gage & Supply Co., 3000 Liberty Ave., GR 1-6600

DISTRIBUTORS

Illinois, Nashville: Clarkson Div. of National Mine Service
Kentucky, Ashland: Ashland Div. of National Mine Service
Jenkins: Kentucky-Va. Div. of National Mine Service
Madisonville: Western Kentucky Div. of National Mine Service
Ohio, Bellaire: Pittsburgh Gage & Supply
Pennsylvania, Altoona: Pittsburgh Gage & Supply
Forty Fort: Anthracite Div. of National Mine Service
Indiana: Whiteman Div. of National Mine Service
Sharon: Pittsburgh Gage & Supply
West Virginia, Beckley: Bemeco Div. of National Mine Service
Logan: All-State Div. of National Mine Service

Morgantown: Mountainer Div of National Mine Service
Parkersburg: Pittsburgh Gage & Supply

McLANAHAN & STONE CORP.

Hollidaysburg, Pa., Phone 5-9807

McNALLY-PITTSBURG MFG. CO.

307 W. 3d St., Pittsburg, Kansas, Phone 542

DISTRICT SALES OFFICES

Illinois, Chicago: 307 N. Michigan Ave., Franklin 2-5172
Ohio, Wellston: P.O. Box 228, Phone 4-2181
Pennsylvania, Pittsburgh 22: First Nat'l Bank Bldg., Grant 1-2640
Australia, Glebe, N.S.W.: A. E. Goodwin Ltd., 47 Forsyth St.
Brazil, Rio de Janeiro: Formac, S.A., Caixa Postal, 1310

MERRICK SCALE MFG. CO.

184 Autumn St., Passaic, N. J.

DISTRICT SALES OFFICES

Illinois, Oak Park: Mr. J. A. Marx, c/o Scoville Park Hotel, Village 8-0500
Missouri, Kansas City 12: W. C. Carolan Co., 612 West 47th St., Jefferson 1-5505
St. Louis: W. C. Carolan Co., 4030 Chouteau Ave., Jefferson 5-5525
Tennessee, Chattanooga 2: Edgar A. Rogers, Chattanooga Bank Bldg., Amherst 7-4640
Virginia, Richmond 19: C. Arthur Weaver Co., Inc., 403 East Franklin St., Milton 31895-6
Canada, Ontario, Toronto 9: Hagan Corp. (Canada) Ltd., P.O. Box 69, Station D, Roger 2-8285

MINE SAFETY APPLIANCES CO.

201 N. Braddock Ave., Pittsburgh 8, Pa., Churchill 1-5900

DISTRICT SALES OFFICES

Alabama, Birmingham: 2500 12th Ave. N., Alpine 4-3403
Colorado, Denver: 2916 Forest St., Florida 5-1588
Kentucky, Harlan: Rio Vista, Phone 130
Pikeville: Hatcher Hotel Bldg., Phone 748
Missouri, St. Louis 3: 1915 Washington Ave., Main 1-2251
Montana, Butte: 2419 Princeton Ave., Phone 6875
Ohio, St. Clairsville: 257 E. Main St., Phone 565
Pennsylvania, Indiana: 241 Elm St., Phone 3-8850
Johnstown: 610 Johnstown Bank & Trust Bldg., Phone 8-2811
Pittsburgh 8: 7519 Penn Ave., Churchill 1-5900
Uniontown: 624 Fayette Nat. Bank Bldg., Geneva 8-7351
Scranton 10: 530 Clay Ave., Diamond 6-3062
Utah, Salt Lake City 1: 257 Rio Grande St., Empire 4-6044
Virginia, Norton: 840 Park Ave., Phone 888
West Virginia, Bluefield: 1513 Bluefield Ave., Davenport 5-8866
Bridgeport: 523 Pennsylvania Ave., Victor 2-3230
Fairmont: 1313 Peacock Lane, Phone 909
Logan: P.O. Box 1306, Phone 1607
Williamson: 38 Sunset Blvd., Phone 1074
Canada, Calgary, Alberta: 3632 Burnsland Rd., Chestnut 3-4092
Nova Scotia, Sydney: 150 Charlotte St., Phone 8370
Ontario, Toronto 4: 500 MacPherson Ave., Walnut 5-1101
Vancouver, B. C.: 3754 W. Tenth Ave., Alma 1127

MINERS' HARDWARE SUPPLY CO.

Martin Bldg., Pittsburgh 12, Pa., Fairfax 1-3013

DISTRIBUTORS

Pennsylvania, Pittsburgh 12: 821 Moravian Way
West Virginia, Bluefield: A. W. Hageman, Box 241

MOBILE DRILLING CO.

960 N. Pennsylvania St., Indianapolis 4, Ind.

DISTRIBUTORS

Arkansas, No. Little Rock: Bailey-Roberts Motors, Inc. 322 W. Broadway, Franklin 5-0134-5
Illinois, Thornton: Prairie State Equipment Co. P. O. Box 376, 107 E. Juliette Street, Trojan 7-5570
Iowa, Cedar Rapids: McNall Machinery & Supply Corp. 600 D. Avenue N. W. Empire 3-3559
Maryland, Baltimore: R. S. Stevenson Company 6301 Blackburn Court, Idlewood 5-8053
Missouri, Kansas City 14: Matchette, Paul L. & Co., 304 West 79 Street Terrace, Delmar 3-6611
Montana, Billings: Western Construction Equipment Co., 505 North 24th Street, P. O. Box 2117 Phone 9-5501
Great Falls: Western Construction Equipment Co., P.O. Box 1504, 2322 River Drive, Glendale 3-1405
North Carolina, Greensboro: King-McIver, Inc. South Elm Street Extension, P. O. Box 1498, BR 5-6177
North Dakota, Fargo: Northwestern Equipment, Inc. on U. S. Highway 10 West, Phone 7583
Minot: Northwestern Equipment Co. of Minot, on U. S. Highway 52 West, Phone 69-111
Tennessee, Knoxville 1: Osborne Equipment Company Market at Front Streets, Phone 5-1177
Memphis: Road Builders Equipment Co., P. O. Box 2858, 285 East Calhoun Street, Jackson 7-9471
Washington, Seattle 4: Air Mac, Inc., 3838 4th Avenue, South, Mutual 3388
Canada, Regina, Saskatchewan: W. F. Fuller Machinery Co., Ltd., 7th Avenue & Halifax Street, JO 9-2288.

MORRIS MACHINE WORKS

Baldwinsville, N. Y.

DISTRICT SALES OFFICES

Illinois, Chicago 6: 205 W. Wacker Dr., RA 6-7174 & 5
New York, New York 1: 254 W. 31st St., PE 6-4523
North Carolina, Charlotte 3: 518 E. Morehead St., FR 7-2678, LD 930
Ohio, Cleveland 14: 446 Leader Bldg., CH 1-5654

SALES AGENTS

Colorado, Denver: Hack Engineering Co., 124 Wazee Market, TA 5-5248
Maryland, Baltimore 18: Jobe & Co., 344 E. 33d St., BE 5-3503 & 5-5033
Missouri, Kansas City 5: Lee-Mathews Machinery & Rental Co., 318 Broadway, Baltimore 1-0650
Ohio, Cincinnati 2: White Industrial Sales & Equipment Co., 140 W. 6th st. Main 1575
Oregon, Portland 4: E. A. Finkbeiner, Lewis Bldg., Capitol 8-2191
Pennsylvania, Philadelphia 4: Maleson Co., 225 N. 32d St., EV 2-6400
Pittsburgh 22: Ramsay Pump & Supply Co., 1701-3 Keenan Bldg., CO 1-1155-6
Scranton: J. A. MacFadyen Co., 537 Washington Ave., DI 2-3993
Tennessee, Chattanooga 2: Edgar A. Rogers, Chattanooga Bank Bldg., AM 7-4640
Texas, Houston 1: Alliger & Sears Co., 2203 Fannin (Box 2217), CA 4-6933
Utah, Salt Lake City 10: Lang Co., 1st S. & 2d West, Phone 3-5831
Virginia, Richmond 19: O'Neil Pump & Engineering Co., 601 E. Franklin St., Phone 7-4828
Washington, Seattle 4: Olympic Supply Co., 1743 1st Ave., S., Seneca 0416
West Virginia, Charleston: Cross Pump & Equipment Co., 2853 Piedmont Rd., Walnut 5-5822
Canada, British Columbia, Vancouver: A. B. Wing Ltd., 1383 Hornsby St., Tatlow 7531
Quebec, Montreal: F. H. Hopkins & Co., Ltd., 8500 Decarie Blvd., Phone 21-7-4737
Ont., Toronto: Taylor Engineering & Const. Co., 111 Stephenson Ave., OX 9-1139

MOTOR EXCHANGE & SUPPLY

Hines, West Virginia, Exeter 2-6801

MYERS-WHALEY CO.

P.O. Box 789, Knoxville 1, Tenn.

N

NACHOD & UNITED STATES SIGNAL CO., INC.

4780 Crittenden Dr., Louisville 9, Ky., EMerson 3-3571

SALES OFFICES

Utah, Salt Lake City: 375 South West Temple DA 2-4311

NATIONAL MALLEABLE & STEEL CASTING CO.

10600 Quincy Ave., Cleveland 6, Ohio

NOLAN CO., THE

Bowerston, Ohio, Phone 6-2771

DISTRIBUTORS

Alabama, Birmingham: Amos A. Culp, 429 So. 24th St., Phone 54-7032
Colorado, Denver 2: E. C. Horne Machinery Co., 1726 Champa St., Tabor 5-7015
Illinois, Chicago: J. N. North Associates, P.O. Box 105, Harbert, Mich., Phone, New Buffalo, Mich., Lakeside 3723 or 4106
Pennsylvania, Pittsburgh: George C. Hutchinson. Jr., 800 Keenan Bldg., Atlantic 1-5860
Wilkes-Barre: John Lloyd & Sons, 33 Bennett Bldg., Valley 4-4691
Utah, Castle Gate: Frank C. Memmott, P.O. Box 154
West Virginia, Huntington: Huntington Supply & Equip. Co., Huntington National Bank Bldg., Jackson 2-5562

P

H. K. PORTER CO., INC., LESCHEN WIRE ROPE DIV.

2727 Hamilton Ave., St. Louis 12, Mo.

DISTRICT SALES OFFICES

California, San Francisco 7: 520 4th St.
Illinois, Chicago 7: 810 W. Washington Blvd.
New Jersey, Newark 5: 219 Emmet St.

SALES AGENTS

Indiana, Bloomington: R. T. Calkins, 1826 E. Hunter Ave.
Ohio, Galena: R. C. Niedringhaus, 11027 Sunbury Rd.
Pennsylvania, Camp Hill: D. D. Somers, 9 Country Club Place
Tennessee, Hermitage: M. M. Muse, Rt. #1
Virginia, Richmond 26: T. E. Turner, 808 Timken Dr.

DISTRIBUTORS

Kentucky, Harlan: Beck Electrical Repair Co.
Lothair: Mine Service Co.
Pennsylvania, Pittsburgh 26: Cobb Wire Rope & Supply, 501 McNeilly Rd.

Continued

Hazelton: Jayem Supply Co., Hazelton-McAdoo Hwy.
Clearfield: Clearfield Equipment Co.

West Virginia, Bluefield: Bluefield Hardware Co.
Huntington: Logan Hdwe. & Sup. Co., P.O. Box 1895
Logan: Logan Hdwe. & Sup. Co., P.O. Box 540
Charleston 23: Capital City Sup. Co., 544 Broad St.
Clarksburg: Osborn Machy. Co., Inc.
Kermit: Controller Block & Sup. Co.
McClure: Erwin Sup. & Hdwe. Co., Inc.
Elkins: Valley Supply Co., Inc.

Tennessee, Nashville: Buford Bros., Inc., 125—10th Ave. S.
Chattanooga: Power Equipment Co., 1080 Duncan Ave.
Knoxville: Power Equipment Co., 1430 Island Home Ave., S.E.
Tidewater Sup. Co. 1506 Island Home Ave., S.E.

Ohio, Cleveland 10: Air Compressors Rental Co., 19615 Nottingham Rd.
Zanesville: Goss Supply Co., 620 Marietta St.
Canton: Ralph Williams, Inc., 429 Waynesburg Rd.

Indiana, Boonville: Vernon Hardware Co., West Side Square
Terre Haute: B. F. Crawford Co., 1921 So. Third St.

Virginia, Norton: Norton Hardware Co., 415 Park Ave.

R

ROBERTS & SCHAEFER CO., DIV. OF THOMPSON-STARRETT CO., INC.

130 N. Wells St., Chicago 6, Ill., Central 6-7292

DISTRICT SALES OFFICES

Pennsylvania, Pittsburgh 22: 1315 Oliver Bldg., Atlantic 18608

West Virginia, Huntington: 916 Fifth Ave., Phone 3-4272

S

SALEM TOOL CO., THE

767 S. Ellsworth Ave., Salem Ohio, Edgewood 7-3416

DISTRIBUTORS

Alabama, Birmingham 4: Cowin Co., 930 2nd Ave. N.

Arkansas, Fort Smith: R. A. Young & Son, Inc.
Little Rock: R. A. Young & Son, Inc., 301 S. 10th St.

Colorado, Denver 16: Union Supply Co., 5460 Colorado Blvd.

Idaho, Boise: Intermountain Equipment Co., Broadway at Myrtle Sts.

Illinois, Mt. Vernon: Ed. Mey Tractor Co.

Indiana, Evansville: Austin Powder Co., Box 177

Iowa, Des Moines: Herman M. Brown Co., First & Sheridan

Kansas, Pittsburg: W. A. Thomas Supply Co., 112-114 W. Pacific

Kentucky, Lexington 6: Wilson Machinery & Supply, 561 W. 4th St.

Montana, Helena: Hall-Perry Machine Co., 123 E. Lawrence St.

New York, New York 6: Exdevco Corp., 19 Rector St.

Ohio, Cincinnati 14: Rish Equipment Co., P.O. Box 120 (Annex Sta.)
Cleveland 29: Rish Equipment Co., P.O. Box 7303
Columbus 11: Rish Equipment Co., P.O. Box 6398, Oakland Park Branch
Dayton 9: Rish Equipment Co., P.O. Box 543
Portsmouth: Rish Equipment Co., P.O. Box 270
Steubenville: Voto Mfg. & Sales Co., 525 N. Webster
Toledo 7: Rish Equipment Co., P.O. Box 206 (Sta. C)
Youngstown 7: Rish Equipment Co., 250 E. Indianola Ave.

Oklahoma, Tulsa: R. A. Young & Son, Inc., 9401 E. Admiral Pl.

Pennsylvania, Bethel Park: Whitmyre Equipment Co., H. Elmer Whitmyre Owner, 336 Sunset Drive
Harrisburg: Capitol Equipment Co., Box 21, Hill Sta., 1151 S. 21st St.
Kingston: Gatti Eng. Co., P.O. Box 1175

South Dakota, Sioux Falls: L. G. Everist, Inc., 201 Paulton Bldg.

Tennessee, Knoxville: Nixon Machinery & Supply Co., 3042 N. Central Ave.

Virginia, Richmond: Rish Equipment Co., P.O. Box 1260
Roanoke: Rish Equipment Co., P.O. Box 1369

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Charleston 22: Rish Equipment Co., P.O. Box 353
Clarksburg: Rish Equipment Co., P.O. Box 2227
Parkerburg: Rish Equipment Co., P.O. Box 1728

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Pennsylvania, Forty Fort: Anthracite Div. of National Mine Service
Indiana: Whiteman Div. of National Mine Service

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Ohio, Cincinnati: 2414 River Road, Garfield 3930
Columbus 4: P.O. Box 935, Hilltop Stat. Broadway 4-1158
Youngstown 7: P.O. Box 1, South Side Stat., Sterling 8-5081

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Du Quoin: Du Quoin Iron & Supply Co., Inc., P.O. Box 181
Marion: N. O. Nelson Co., 600 N. Van Buren St.
Mt. Vernon: Central Mine Supply Co., Box 538
Murphysboro: Egyptian Sales Agency, 401 S. 17th St.
Peoria: Couch & Heyle, 1016 S. Adams

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Drillmaster Supply Co., 1117 E. Division St.
Orr Iron Co., 1100 Pennsylvania St.
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McComb Supply Co., Inc.
Hazard: Sterling Hardware Co., Inc., 124 Main St.
Madisonville:
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Woodruff Supply Co., Lincoln Ave.
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E. A. Kinsey Co., 331 W. 4th St.
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Banks-Miller Supply Co., 330 3d Ave.
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Guyan Machinery Co., Inc.
Logan Hardware & Supply Co., 300 Highland Ave.
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Shinnston: Erwin Supply & Hdwe., Inc., P.O. Box 247
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Ohio, Columbus: 1870 Langham Road HU 6-1755
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Utah, Salt Lake City: P.O Box 2548, 2300 So. Main Street IN 6-8668
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SEARCHLIGHT ADVERTISERS' INDEX
1958 COAL AGE MINING GUIDEBOOK & BUYING DIRECTORY

Classifications of the products or services offered by the SEARCHLIGHT advertisers in this issue.

1 Appraisals
2 Belt Conveyors
3 Bulldozers, Tractors, Scrapers and Graders
4 Chain Conveyors
5 Clamshell Buckets
6 Coal Bins
7 Coal Crushers
8 Compressors
9 Converters
10 Conveyor Belting
11 Conveyor Pulleys
12 Cost Reduction Programs
13 Cutting Machines
14 Diesel Locomotives
15 Diesel Sets
16 Dippers
17 Draglines
18 Drills
19 Elevators
20 Fans and Blowers
21 Feeders
22 Hoists
23 Idlers, belt type
24 Loading Machines
25 Locomotives
26 Locomotive Cranes
27 Mine Cars
28 Motor Generators
29 Motors, Starters, A.C., D.C.
30 Outside Mining Equipment
31 Parts
32 Plant Dismantling
33 Portable Cord
34 Pumps
35 Rail and Accessories
36 Railroad Cars, all types
37 Railroad Car Leasing
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41 Rock Dusters
42 Scrap Iron and Steel
43 Screens
44 Shovels
45 Shuttle Cars
46 Steel, Structural and Plates
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48 Supplies
49 Switch Material
50 Tipple Equipment
51 Track Equipment
52 Trackless Equipment
53 Transformers
54 Trucks, all types
55 Underground Mining Equipment
56 Valves and Fittings
57 Wire and Cable

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Joy 12 BU Loaders, 8E, AC and DC.
Joy 20 BU Loaders, latest type.
Joy 11 BU Loaders, latest type.
Joy 8 BU Loaders, long and short head.
Joy 8 BU Loaders, 34" hi, AC and DC.
Reliance Motors, 4 to 10 H. P., for above.
Goodman 660 and 665 Loaders on cats.
Goodman 460 Loader, like new.
Myers Whaley and Clarkson Loaders.
Joy 8SC and 6SC Shuttle Cars.
Joy 5SC and 42E15 Shuttle Cars.
Joy 32E16, 32E15 and 32E9 Shuttle Cars.
Joy CD-22 Drills on rubber.
Joy T2-5, T2-6 and T1 Cat Trucks.
Joy 11RU and 10RU rubber tired Cutters.
Jeffrey 70 URB rubber tired Cutters.
Jeffrey 29 UC Cutters on Cats.
Joy 11B and 7B Cutting Machines AC and DC.
Goodman 512 Cutting Machines with bugdusters, AC and DC.
Goodman 112 and 12AA Cutting Machines, AC and DC.
Jeffrey 35-L, 35-B and 35 BB Cutters, AC and DC.
Jeffrey 29C and 29L Cutting Machines on track.
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Jeffrey, type MH-110, 13 & 10 ton, 36" to 48" Track Gauge.
Jeffrey, type MH-78, 10 ton, 42", 44", and 48" Gauge.
Jeffrey, 4 ton, 6 ton, and 8 ton Locomotives, all gauges.
Jeffrey, type MH-124 and 2186, 6 ton, 24" O.A. height.
G. E., 6 ton, types 801, 803, 821 Locomotives, 42", 44" & 48" Ga.
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Cedar Rapids portable Screening Plant.
Complete five track tipple with washer.
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Belt Loading Booms, Crushers, double and singleroll.
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Jeffrey and Joy 12", 15" and 20" Chain Conveyors.
G. E. and Westinghouse Rotary 100/200/300/500 KW, 300 to 600 volt DC Converters.
Transformers for above 2300/4000/6600/12000
G. E. and Westinghouse Motor Generator Sets, 150 to 300 KW, all voltages.

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900 H. P. Shaft Hoist.
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Joy and Acme self propelled rubber tired Compressors.
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Rock Dusters, all sizes and types.
Mine Cars, all sizes, gauges and types.
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Relaying Rail, 25# to 80#.
All sizes Copper Trolley and Feeder Line.
Distributor Transformers 1 to 4500 KVA 110/13000 volts
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Huge stock of mine supplies and thousands of other items.
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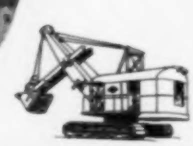
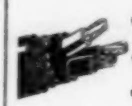


EVERY TYPE OF ELECTRIC WIRE & CABLE FOR MINING IN STOCK AT BARGAIN PRICES



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- *MINING MACHINE*
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NEW CURRENT MODELS — IMMEDIATE SHIPMENT FROM OUR FACTORY — WRITE WIRE OR PHONE

NEW BONDED® TROUGHING IDLER CONVEYOR BARGAINS

Remember, You Save Up to 50%

CONVEYOR PRICES INCLUDE BELTING

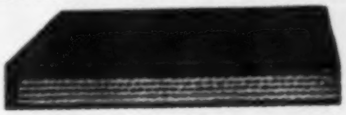
Complete Pre-Fab sections of 8" Jones & Laughlin Jr. I Beam Frame Conveyors quickly and easily joined together on the job. These beams are rolled with .20% Copper Content. Atmospheric exposure tests disclose that Junior Beams with .20% Copper have as much as four times the resistance to corrosion as non-copper steels. Braced with structural angle, welded to frame for maximum rigidity. Equipped with 5" roll diameter idlers and return rolls, 20" diameter head pulley and 16" diameter tail pulley, mounted on 2⅛" or 2 7/16" diameter shaft. We take our loss on our stock of short length belting. You can save as much as 50% on BONDED CONVEYOR SPECIALS, with conveyor belting in two pieces. Belt is new 4-ply, 28 oz. duck, ⅛" top rubber cover x 1/32" bottom cover Major grade belt and is Fresh Stock made by leading manufacturers.

WRITE FOR BULLETIN #1138.

Belt Width	Length of Conveyor	List Price	Sale Price	Add or Deduct Per Foot
18"	25'	$1477	$ 794	For longer or shorter lengths
18"	45'	2217	1165	
18"	70'	3142	1648	
18"	85'	3697	1933	
18"	100'	4252	2220	
18"	130'	5362	2797	$19.24
20"	25'	1517	828	20.37
20"	60'	2882	1533	
20"	75'	3467	1838	
20"	90'	4052	2145	
24"	25'	1590	898	21.78
24"	45'	2430	1330	
24"	70'	3480	1875	
24"	100'	4740	2514	
24"	120'	5580	2950	
24"	150'	6840	3603	
30"	50'	2911	1617	24.75
30"	70'	3871	2119	
30"	90'	4831	2614	
36"	25'	1618	1118	27.95
36"	45'	2858	1678	
36"	60'	3638	2096	
36"	100'	5718	3214	

NEW CONVEYOR BELTING SAVE UP TO 30%

WE PAY FREIGHT ON 200 POUNDS OR OVER



Major Brand: 12# to 15# Average Friction Pull. 800# to 1000# Average Cover Tensile. Heavy Duty 4-ply, 28-oz. duck, ⅛" top rubber cover x 1/32" bottom rubber cover belting having high tensile strength, tough cotton duck, strong carcass and proper flexibility. For heavy boxes, bags and bulk materials. Troughs easily. Famous brands at deep cut prices. Fresh stocks.

Width	Ply	List Price	Sale Price
18"	4	$4.51 foot	$3.29 foot
20"	4	4.97 foot	3.80 foot
24"	4	5.85 foot	4.26 foot
30"	4	7.18 foot	5.21 foot
36"	4	8.51 foot	6.13 foot

Major Bee Brand: 16# to 19# Average Friction Pull, 2500# to 3000# Average Cover Tensile. Skim coat between plies.

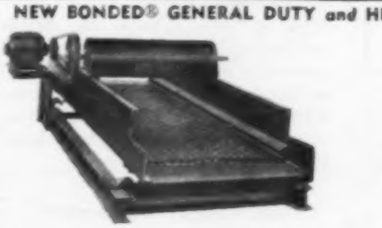
A high grade of heavy duty 4 and 5-ply, 28 oz. duck, ⅛" top rubber cover x 1/32" bottom rubber cover. These belts are for more severe service, high tonnages and abrasion resistance. For handling stone, mineral ores, concrete, cement, coal, and other similar materials, both wet and dry. Belts have molded rubber edges.

Width	Ply	List Price Per Ft.	List Price Per Ft.
18"	4	$ 5.39 foot	$3.83 foot
20"	4	5.90 foot	4.37 foot
24"	4	6.94 foot	4.94 foot
30"	4	8.53 foot	6.07 foot
30"	4	10.09 foot	7.35 foot
24"	5	8.14 foot	5.78 foot

Other widths, plies, duck weights and cover thickness available at low prices.

WRITE FOR FREE SAMPLE AND BULLETIN #1209.

NEW BONDED® GENERAL DUTY and HEAVY DUTY VIBRATING SCREENS



For mineral, chemical and other industrial products. Fast, efficient and economical for cleaning, sizing, grading, dewatering. Made in all metals, including stainless steel. Enclosed models for hot materials or dust control. Bonded screens are built for any screening operations, wet or dry.

GENERAL DUTY SCREENS, TYPE AS: Eccentric weight mechanism, spring mounted, 1 to 3 decks, 2' x 4' to 3' x 8'.

WRITE FOR BULLETIN #1086.

Priced from $443.00

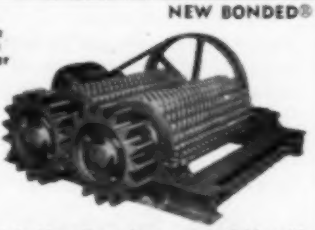
HEAVY DUTY MODELS, TYPE BS: Four bearing positive throw eccentric shafts; 3' x 6' to 5' x 14', 1 to 5 decks.

WRITE FOR BULLETIN #1087.

Priced from $1445.00

NEW BONDED® COAL CRUSHERS

Single Drive Crusher



Bonded double roll crushers are available with single and double drive, in a wide range of roll diameters and face widths. Capacities from small to 100 tons per hour. Tooth roll models are for primary and secondary crushing of coal from stoker to 8". Will take feed sizes to 24". Teeth are designed to break materials sharp and clean with accurate sizing and a minimum of fines. Bonded double drive crushers are for larger resultant sizes to 8". All models are available with fine corrugated or smooth rolls or any combination of same for crushing Cinders, Pumice, Perlite, Other Expanded Lightweight Aggregate, Chemicals, Limestone Chips, Fertiliser and many other materials.

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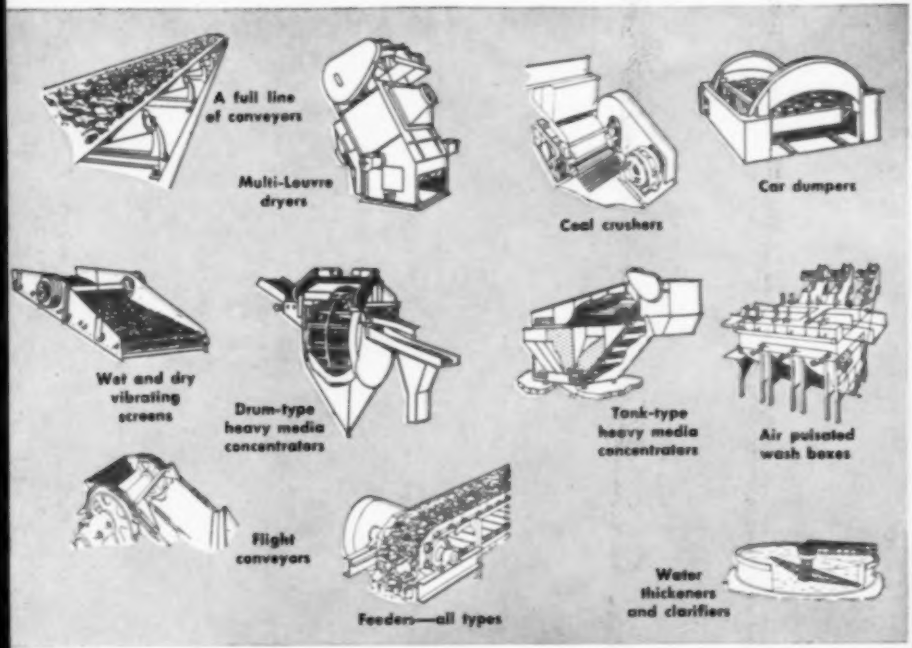

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